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DOCTORAL DISSERTATION

Evolutionary Patterns Within the Anthozoa (Phylum Cnidaria) Reflected in Ribosomal Gene Sequences

by

Ewann Agenbroad Berntson

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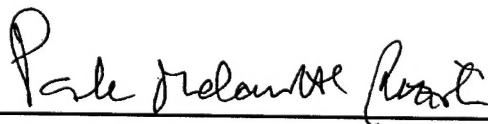
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Evolutionary patterns within the Anthozoa (Phylum Cnidaria) reflected in ribosomal gene sequences

By

Ewann Agenbroad Berntson

B.Sc., University of Washington
(1991)

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

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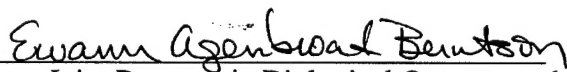
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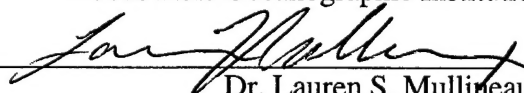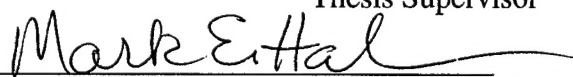
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Woods Hole Oceanographic Institution

This thesis is dedicated
to the memory of
Jessica Wallace

You supported me through graduate school
in more ways than you can know.

You instilled in me an appreciation for the
truly important things in life.

You convinced me that I could make it
to the top of that mountain.
You were right, you know -- the view is
worth every step.

Evolutionary patterns within the Anthozoa (Phylum Cnidaria) reflected in ribosomal gene sequences

by

Ewann Agenbroad Berntson

Submitted to the Department of Biological Oceanography in April, 1998
in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

Abstract

This thesis project assesses phylogenetic relationships within the phylum Cnidaria, at the subclass level within the Class Anthozoa, and at the ordinal level within the Subclass Octocorallia. Traditional cladistics using morphological data have resulted in disagreements over taxonomic relationships, primarily due to a paucity of morphological characters within the Anthozoa and ambiguity about the significance of any given character. I have used DNA sequence information to help resolve some of these issues. These phylogenetic studies contribute to the understanding of divergence within the class Anthozoa.

Museum collections of preserved flora and fauna historically used for morphological studies are now increasingly being utilized for addressing genetic questions. The extraction of DNA from ethanol-preserved specimens of recent origin is practiced routinely, but genetic analyses of long-preserved specimens have inherent difficulties due to the slow degradation of DNA. The goal of this study was to demonstrate the feasibility of isolating genomic DNA from museum specimens of octocorals and amplifying the nuclear 18S ribosomal RNA gene. The DNA sequence for the complete 18S rRNA gene can then be determined. Techniques were designed to solve several problems for obtaining genetic sequences from museum specimens. The DNA extractions of museum specimens yielded only small amounts of DNA of very low molecular weight, which limits the length of Polymerase Chain Reaction (PCR) products that can be generated with standard protocols. I was successful in producing PCR fragments from museum specimens by performing an extended tissue digestion on the archival specimens, running an initial PCR reaction, and then following with a reamplification of the original PCR product. The use of taxon-specific PCR primers decreased the risk of amplifying contaminant DNA rather than the target DNA in archival specimens. The combination of our modified extraction protocol and PCR reamplifications with taxon-specific PCR primers allowed me to generate 700- to 1800-basepair sequences from 16 specimens from three different museum collections that had been preserved for up to fifty years.

Taxonomic relationships within the corals and anemones (Phylum Cnidaria: Class Anthozoa) are based upon few morphological characters: colony morphology and the structure of the tentacles, gastric mesenteries, nematocysts, and skeletal axis. The significance of any given character is debatable, and there is little fossil record available for deriving evolutionary relationships. In this study I use complete sequences of 18S ribosomal DNA to examine subclass-level and ordinal-level organization within the Anthozoa. I investigate whether the traditional two-subclass system (Octocorallia, Hexacorallia) or the current three-subclass system (Octocorallia, Hexacorallia, Ceriantipatharia) is better supported by sequence information. I also examine the phylogenetic affinities of the anemone-like species *Dactylanthus antarcticus* and the putative antipatharian *Dendrobrachia paucispina*. Thirty-eight species were chosen to

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maximize the representation of morphological diversity within the Anthozoa. Maximum likelihood techniques were employed in the analyses of these data, using relevant models of evolution for the 18S rRNA gene. I conclude that placing the orders Antipatharia and Ceriantharia into the Subclass Ceriantipatharia does not reflect the evolutionary history of these orders. The Order Antipatharia is closely related to the Order Zoanthidea within the Hexacorallia and the Order Ceriantharia appears to branch early within the Anthozoa, but the affinities of the Ceriantharia cannot be reliably established from these data. My data generally support the two-subclass system, although the Ceriantharia may constitute a third subclass on their own. The Order Corallimorpharia is likely polyphyletic, and its species are closely related to the Order Scleractinia. *Dactylanthus*, also within the Hexacorallia, is allied with the anemones in the Order Actiniaria, and their current ordinal-level designation does not appear to be justified. The genus *Dendrobrachia*, originally classified within the Order Antipatharia, is closer phylogenetically to the Subclass Octocorallia. The 18S rRNA gene may be insufficient for establishing concrete phylogenetic hypotheses concerning the specific relationships of the Corallimorpharia and the Ceriantharia, and the branching sequence for the orders within the Hexacorallia. The 18S rRNA gene has sufficient phylogenetic signal, however, to distinguish among the major groupings within the Class Anthozoa, and I can use this information to suggest relationships for several enigmatic taxa.

The Subclass Octocorallia (Phylum Cnidaria: Class Anthozoa) is comprised of the soft corals, gorgonian corals, and sea pens. The octocorals have relatively simple morphologies, and therefore few characters upon which to base taxonomic systems. Historically, the Subclass Octocorallia was divided into seven orders: Helioporacea (Coenothecalia), Protoalcyonaria, Stolonifera, Telestacea, Alcyonacea, Gorgonacea, and Pennatulacea. It has been argued that this arrangement exaggerates the amount of variability present among the species of the Octocorallia. The current taxonomy recognizes the two orders of Helioporacea (blue corals) and Pennatulacea (sea pens), and assembles the remaining species into a third order, Alcyonacea. The species within the Alcyonacea exhibit a gradual continuum of morphological forms, making it difficult to establish concrete divisions among them. The subordinal divisions within the Alcyonacea correspond loosely to the traditional ordinal divisions. In this study I address the validity of the historical ordinal divisions and the current subordinal divisions within the Subclass Octocorallia. I also explore the phylogenetic affinities of the species *Dendrobrachia paucispina*, which was originally classified in the Order Antipatharia (Subclass Ceriantipatharia). Polyp structure indicates a closer affinity between *Dendrobrachia* and the Subclass Octocorallia. I have determined the nuclear 18S rRNA sequences for 41 species of octocorals, and use these to construct a molecular phylogeny of the subclass. I utilize Maximum Likelihood techniques, employing a realistic model of evolution given these species and this data set. The most likely trees from these sequence data do not support the morphological taxonomy of the Octocorallia. The Order Pennatulacea is the most cohesive group within the subclass, but is not monophyletic. The most likely trees indicate three primary clades, one of which is undifferentiated and contains half of the species in this analysis. These data cannot distinguish among the branching order of these three clades. The morphological character of dimorphism (the presence of both autozooids and siphonozooids within a single colony) corresponds loosely with the topology of the most likely trees, and the monophyly of dimorphism cannot be rejected from these data. The species *Dendrobrachia paucispina* has a close affinity with the genera *Corallium* and *Paragorgia* (Alcyonacea: Scleraxonia), although its morphology suggests it is more similar to the genus *Chrysogorgia*. The genetic divergence found within genera is approximately equivalent to that found in other invertebrates, but the divergence found within families is greater in the octocorals than in other invertebrates. This difference may reflect the inappropriate inclusion of evolutionarily divergent genera within octocorallian families. This study is more thorough than other anthozoan molecular phylogenetic studies to date. I

have employed appropriate evolutionary models for maximum likelihood analyses, utilizing complete 18S rDNA sequences from the majority of families within the Octocorallia. Many of the relationships within the Octocorallia, however, remain ambiguous.

Thesis Supervisor: Dr. Lauren Mullineaux
Title: Associate Scientist, Woods Hole Oceanographic Institution

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As anyone who has ever conducted research knows, a project is rarely completed that didn't rely heavily upon help from others. Doctoral thesis projects are particularly good examples of this. I have been surrounded by numerous people who have generously donated their time, supplies, expertise, and specimens to help me, some doctoral student they had never heard of. Without them, my thesis project would have been woefully incomplete. And then there are those who have aided in the aspects of my life outside of science. They have given me support and friendship and chocolate regardless of how successful my analyses were that day. Their names won't appear on any of the papers I may publish, but their support was critical and very much appreciated.

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afforded me an ally in listening to country music, eating chocolate, and playing pinochle and underwater hockey. She taught me how to swingdance on the deck of a moving ship (although never quite got me to stop looking terrified in the process) and how to find the best ceviche street stand in Mexico. She convinced me I could do anything I wanted to, even finish my thesis. (See girlfriend, you were right as always!)

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Chapter 1

Introduction

Knowledge of evolutionary systematics is fundamental to our understanding of the processes that influence the biological world. Life on this planet survives thanks to a complicated web of interactions involving species from microbes to mammals. The faunal diversity that exists today is the result of evolutionary processes acting over millions of years. The forces behind evolution, and the details of how species change, are not well-understood. Evolutionary changes cannot be observed directly on the time-scale of a human lifetime, so insight into these processes must be gained from other lines of evidence. The fossil record is invaluable for reconstructing morphological change. Not all species are readily fossilized, however, and often one must rely upon comparisons of existing morphological forms to hypothesize evolutionary relationships.

Evolutionary relationships among species can be reconstructed by comparing character traits, assuming that species sharing the greatest number of common traits are the closest relatives of one another. Traditionally, morphological characteristics were used to determine phylogenies because the genetic changes behind those morphological traits were inaccessible or unknown. With the advent of molecular techniques, we can use protein and DNA sequence information as additional characters to reconstruct phylogenetic relationships. DNA sequence information can be useful in determining relationships where morphological associations are ambiguous or contradictory and a fossil record is lacking. A combination of morphological and molecular information will provide the maximum number of characters upon which to base a taxonomic system.

This thesis examines phylogenetic relationships within the Class Anthozoa (Phylum Cnidaria). Cnidarians are some of the simplest of the invertebrates morphologically. They are diploblastic, possess a single body opening into a gastrovascular cavity, and have no specialized system for gas exchange, excretion, or circulation. The phylum is characterized by the presence of tentacles armed with stinging nematocysts. Many species exhibit an alternation of generations between a medusa stage

and a polyp stage. The species of the Class Anthozoa (anemones, corals, and sea pens) lack the medusa stage, and are exclusively polypoid.

An early taxonomic classification of the Anthozoa recognized two subclasses (e.g. Minchin et al. 1900, Deichmann 1936, Hyman 1940) (Fig. 1A). The Subclass Hexacorallia contained the stony corals (Scleractinia), anemones (Actiniaria), the black corals (Antipatharia), tube-anemones (Ceriantharia), and other anemone-like species (Zoanthidea and Corallimorpharia). The Subclass Octocorallia contained the blue corals (Helioporacea), soft corals (Alcyonacea), gorgonian corals (Gorgonacea), and sea pens (Pennatulacea). The subclass-level divisions were based primarily on the numbers of tentacles (eight in the Octocorallia vs. multiples of six in the Hexacorallia) and the number of divisions within the gastrovascular cavity, termed septa or mesenteries (eight unpaired in the Octocorallia vs. multiples of six paired in the Hexacorallia). The ordinal-level divisions within the Hexacorallia were based on the type of skeleton present, if any, and finer distinctions in the mesenteries and tentacles. The ordinal-level divisions within the Octocorallia were based on attributes such as colony structure, skeletal composition and arrangement, and the structure and location of extraskeletal calcium spicules (Wells & Hill 1956a).

The current taxonomic system, proposed as early as the 1890's (van Beneden 1897) but not adopted until the 1950's, recognizes three subclasses within the Anthozoa (Fig. 1B). The orders containing the black corals and the tube anemones were removed from the Hexacorallia and placed within their own Subclass, the Ceriantipatharia. This revision was based on two characters: the resemblance of the larval cerianthid (the cerinula) to the adult antipatharian polyp, and weak and indefinite mesentery musculature (Wells & Hill 1956b). The Subclass Octocorallia was also revised based on the hypothesis that the species of the Octocorallia were not sufficiently different from one another to warrant distinction at the ordinal level (Bayer 1981). The new octocorallian classification

Class Anthozoa
    Subclass Hexacorallia
        Order Actiniaria
        Order Zoanthidea
        Order Corallimorpharia
        Order Scleractinia
        Order Antipatharia
        Order Ceriantharia

    Subclass Octocorallia
        Order Helioporacea (=Coenothecalia)
        Order Protoalcyonaria
        Order Stolonifera
        Order Telestacea
        Order Alcyonacea
        Order Gorgonacea
        Order Pennatulacea

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Class Anthozoa
    Subclass Hexacorallia
        Order Actiniaria
        Order Zoanthidea
        Order Corallimorpharia
        Order Scleractinia

    Subclass Ceriantipatharia
        Order Antipatharia
        Order Ceriantharia

    Subclass Octocorallia
        Order Helioporacea
        Order Alcyonacea
            Suborder Protoalcyonaria
            Suborder Stolonifera
            Suborder Alcyoniina
            Suborder Scleraxonia
            Suborder Holaxonia
        Order Pennatulacea

B

Fig. 1   **Historical and revised taxonomic divisions within the Class Anthozoa.**
        A. Traditional classification, e.g. Minchin et al. (1900), Deichmann (1936), Hyman (1940).
        B. Revised classifications, e.g. van Beneden (1897), Bayer (1981).

system retained the orders Helioporacea and Pennatulacea, and combined the remaining species into the Order Alcyonacea. The previous ordinal divisions were loosely maintained at the subordinal level within the Alcyonacea.

The Anthozoa have a relatively simple morphology, with few characters on which to base their taxonomy. The divisions within the Hexacorallia can include differences in the numbers of tentacles and mesenteries, as well as the presence or absence of a skeleton, but the octocorals all have the same number of tentacles and mesenteries, reducing the number of characters even further for defining groups within the subclass. Morphological characters are so few in the octocorals that sometimes an entire group is defined by a single character (Hickson 1930). The various taxonomic arrangements have arisen from differing interpretations of the significance of these characters (e.g. Broch & Horridge 1957 vs. Bayer 1993, concerning spicule morphology). The fossil record for the anthozoans is incomplete, because many of the species lack any solid skeleton which would be preserved more readily.

Genetic data can be particularly useful for investigating these types of taxonomic relationships. Many genes are found universally in all living species, and can therefore be compared directly. This is true for very few morphological characters. Different regions of DNA evolve at different rates as a result of functional constraints, so a genomic region can be selected to be appropriate for the scope of the evolutionary question addressed. New methods of analysis have recently become tractable for large data sets. Researchers can now use appropriate models of evolution in their analyses, reducing the error introduced into the analysis from incorrect assumptions about the way genes evolve.

In this thesis work, I used molecular phylogenetic methods to address questions of evolution within the Class Anthozoa. I sought to determine whether traditional morphological taxonomy or recent taxonomic revisions more accurately reflect the phylogeny of the class. Two specific questions pertaining to the Class Anthozoa have

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arisen from conflicts in the interpretation of morphological data. The first question addresses the validity of the Subclass Ceriantipatharia within the Anthozoa. The placement of Ceriantharia and the Antipatharia in a separate subclass argues that these groups are of an evolutionary lineage separate from that of the other Anthozoa. A more fundamental aspect of this question is whether the ordinal divisions within the Hexacorallia and Ceriantipatharia, which are based exclusively on morphological differences, reflect the phylogeny of these species.

The second question concerns the degree of genetic divergence among the major groups within the subclass Octocorallia, and whether the morphologically recognized divisions correspond to genetic associations found. I examined whether genetic divergence indicates that the morphological groups should be distinguished at the ordinal or subordinal level. The separation of groups at the ordinal level indicates these groups are more distinct from each other than if they were separated at the subordinal level. The revised taxonomy (Bayer 1981) suggests a closer relationship among the alcyonacean suborders than among the orders Helioporacea, Alcyonacea, and Pennatulacea. Measures of sequence divergence will indicate the relative differences within and among the seven historically recognized orders. If divergence is lower among the suborders of the Alcyonacea than among the orders Helioporacea, Alcyonacea, and Pennatulacea, this would suggest that the Order Alcyonacea with the current subordinal divisions is a more accurate reflection of the evolutionary history of the Octocorallia.

This thesis project also examined the phylogenetic affinities of two taxa with intriguing morphologies. The first is the species *Dactylanthus antarcticus*, which is a member of the Order Ptychodactiaria within the Subclass Hexacorallia. The Ptychodactiaria are anemone-like, and were historically members of the Order Actiniaria (the anemones). Their musculature, nematocysts and mesenterial structure were subsequently deemed ancestral and unique from the other Actiniaria, and a new order was

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created for them (Wells & Hill 1956c). The second species, *Dendrobrachia paucispina*, was originally classified with the Order Antipatharia (black corals) based on its skeletal axis. Recent examinations of polyp morphology suggest that *Dendrobrachia* is actually a member of the Octocorallia. Molecular information was utilized to clarify the phylogenetic affinities of these unusual species.

I acquired individual specimens or DNA from species representing all of the orders and the majority of the suborders and families in the Class Anthozoa in order to construct a molecular phylogeny of the class. Species from all orders and most suborders of the Hexacorallia were obtained for my analyses, as well as members of 22 of the 30 extant families of the Octocorallia. This sampling scheme was devised to include representatives from across the morphological breadth of the Class Anthozoa.

Specimens were collected by submersible from Fieberling Guyot in 1990 and Hawaiian seamounts in 1993 and 1996, and in coastal environments in the U.S., Bermuda, New Zealand, the Red Sea, and Panama. Sequences were determined from twelve alcohol-preserved specimens from the National Museum of Natural History, the Harvard Museum of Comparative Zoology, and the Bermuda Aquarium, Natural History Museum and Zoo.

Molecular Techniques

There are many steps in the progression from specimen to phylogenetic tree. Recent technological advances have improved the accessibility, quality and speed of many of the steps of phylogenetic analysis. Advances in analytical methods have accompanied the advances in techniques, providing a clearer understanding of molecular evolutionary processes in the natural world. As a result, the appearance of molecular phylogenies in the recent literature has increased geometrically.

Selection of a Genomic Region

Organismal phylogenies using molecular data are based on the assumption that a specific genomic region is representative of the evolutionary history of the entire genome. Sequence information from a single gene or portions of several different genes are evaluated because it is impractical to obtain the sequence of an entire genome. Each genomic region evolves at a specific rate determined by its structural and functional constraints, so a particular region must be selected that is appropriate for the phylogenetic question. A gene that evolves too slowly will yield insufficient genetic differences to indicate phylogenetic relationships among closely related taxa. A gene that evolves too rapidly will be difficult to align among species that are evolutionarily divergent. Genetic divergences greater than 30% indicate the sequences are essentially randomized, and therefore difficult to align with certainty (Hillis & Dixon 1991). Appropriate genomic regions must be chosen for addressing evolutionary relationships at the taxonomic levels under investigation.

Two basic types of genes that have been used for reconstructing molecular phylogenies are protein-coding genes and ribosomal genes. Protein-coding genes are constrained in the ways they can evolve because they must produce a functional protein. Ribosomal RNA genes, found in both the nucleus and mitochondria, do not produce a protein, but form part of an RNA and protein complex that builds other proteins. The RNA within these ribosomal complexes have extensive secondary structure, including regions that must maintain base-pairing with other portions of the RNA (stem regions), as well as regions which do not engage in base-pairing (loop regions) and are therefore less constrained. Because of these structural constraints, ribosomal RNA genes have domains that evolve at different rates, making them appropriate for phylogenetic analysis at a variety of taxonomic levels.

Nuclear ribosomal RNA genes are used frequently to address phylogenetic questions at a variety of taxonomic levels. In particular, the small-subunit 18S rRNA gene has proven useful for phylogenetic inquiries at the phylum level (e.g. Wainright et al. 1993), the ordinal level (e.g. Kelly-Borges et al. 1991, Hay et al. 1995) and the family level (e.g. Kuznedelov & Timoshkin 1993, Fitch et al. 1995). The questions I address in this thesis fall within this range, suggesting that the nuclear 18S rRNA gene is appropriate for this work. Although the 18S rRNA gene is fairly large (roughly 1800 basepairs in cnidarians), the availability of automated sequencers facilitates the sequencing process greatly. It is no longer prohibitive to generate many DNA sequences from genomic regions of this size.

Generating DNA Sequences

The determination of DNA sequences relies upon the generation of large quantities of DNA from the genomic region of interest. This was a time-consuming process in the past: the region of interest was identified through restriction digests and probing, the sample DNA was cloned into bacterial colonies, and then the colonies were grown and harvested to produce sufficient quantities of DNA to determine the sequence.

Undeniably, the most significant recent advance in molecular techniques as they relate to the generation of DNA sequences is the Polymerase Chain Reaction (PCR). PCR was first described in 1987 (Mullis & Faloona 1987). It is a process by which a particular genomic region can be copied exponentially by mimicking the cellular DNA replication cycle. DNA polymerase and individual nucleotides are added to the DNA template, along with small single-stranded (oligonucleotide) primers that anneal to the ends of the sequence to be determined. The regions flanking the gene of choice must therefore be known in order to design appropriate oligonucleotide primers. PCR is a highly effective procedure, producing a 200,000-fold increase in the target sequence in 20 cycles by starting with 1 μg

of total DNA (Mullis & Faloona 1987). The target sequence can be present in very minute quantities, which makes this procedure applicable for working with museum specimens, where tissue samples are limited and the majority of the DNA in the specimen may be damaged or degraded.

For my project, I performed PCR amplifications of the nuclear 18S rRNA gene, and I cloned the PCR fragments into bacterial colonies. There are three primary reasons for this approach. First, cloning gave me a permanent record of my PCR amplifications to which I could return if needed. Additionally, methods for determining the sequence of PCR products require large concentrations of those products. Generating large amounts of PCR product is routine from fresh or frozen specimens, but this was rarely the case with the museum specimens. Lastly, cloning the PCR fragments allowed me to determine the sequence for the entire fragment. Normally, the ends of the DNA template are 'lost' in the sequencing process, because sequencing primers must be slightly internal to the PCR primers to produce a clean DNA sequence. If the PCR fragment is cloned, however, one can begin the sequencing reaction within the bacterial vector, and read the entire PCR fragment.

I used the TA-cloning method (Invitrogen Corporation) in my protocol. TA-cloning takes advantage of a biochemical characteristic of the PCR reaction: *Taq* DNA polymerase adds an additional adenosine (A) nucleotide to the end of every synthesized DNA fragment. The bacterial vector is designed to have single thymidine (T) nucleotide on its ends which will pair-bond with the ends of the PCR fragments, and splice the DNA fragment into the vector. The vector with the PCR fragment is then transformed into bacterial cells, where it replicates along with the bacterial DNA replication system. The cells are grown on solid medium, and are harvested and their DNA extracted to be used as the template for the DNA sequencing reaction.

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I utilized Licor automated sequencers for the bulk of this thesis project. I employed the dideoxy sequencing method (the Sanger method) for the sequencing reaction, with an infrared label on the sequencing primers. I performed six sequencing reactions for each specimen, with three primers along each strand of DNA for both strands. I determined the sequences for each strand in order to verify that the sequence was internally consistent. The images were analyzed using the BioImage program, which read the gels and assembled the individual reactions to form contiguous sequences.

Sequence Analysis

Once the sequences have been determined for a group of organisms, phylogenetic inferences can be made about those organisms based on the similarities and differences of their sequences. The first step in comparing sequences is to align them (Fig. 2A). An alignment can be thought of as an hypothesis of positional nucleotide homology. An alignment asserts that all nucleotides at a given position would share a common ancestral nucleotide. Computer programs are available that will align sequences, although many alignments can be constructed easily by eye. Sequence similarity is the primary basis by which sequences are aligned, but such alignments are subject to homoplasy (two nucleotides are the same at a given position through parallel evolution, not because they have a common ancestor). The use of stem and loop structure can be beneficial when aligning ribosomal sequences, incorporating knowledge of secondary structure. However an alignment is created, it is absolutely critical that the alignment be accurate before proceeding with further analyses. All phylogenetic analyses assume the alignment is correct, since the analyses intend to compare homologous characters. For this reason, any regions of the alignment that are ambiguous or difficult to align with certainty should be removed from the data set.

Anthozoan 1   C-CGCCTGTGGTGATTCATA
Anthozoan 2   CGCGCCTGTGATGATTCAGA
Anthozoan 3   AACGGCCGTGGTGATTCATA
Outgroup   GACGTCAGTCATCTTTAACT

A
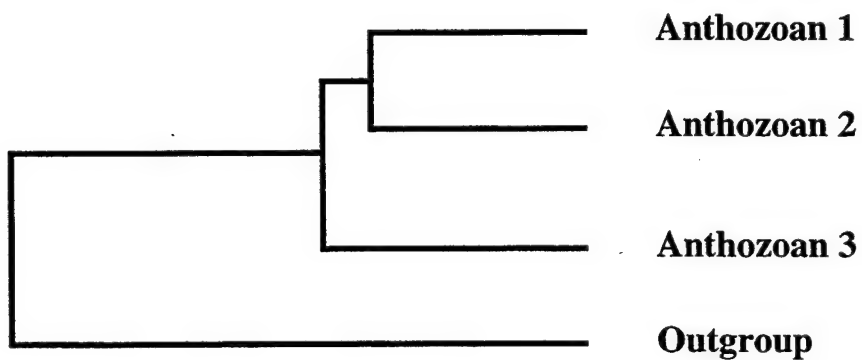
B

Fig. 2   **Examples of a sequence alignment and phylogenetic tree**
               A. Sample alignment of three theoretical species.
               B. Hypothetical tree built from the above sequences.

The product of a phylogenetic analysis is a tree depicting relationships among the taxa included in the analyses (Fig. 2B). The individual taxa are found at the tips of the branches, and the branching pattern organizes the taxa into groups based on hypothesized evolutionary relationships. As one moves from the tips of the tree back to the base, one is moving back in time, retracing the development of the lineage of organisms. Each tree is considered an evolutionary hypothesis, based on the data presented and the algorithm used, representing proposed evolutionary relationships among the members of the tree. Therefore, trees of differing topologies are considered alternative evolutionary hypotheses.

The topological positions of taxa on a tree convey specific relationships among those taxa. A group of taxa that are united into a single cluster, joined together at a common base, is called a clade. Stated in a slightly different way, a clade constitutes a single point on the tree and all descendents. A group of taxa is considered monophyletic if all taxa in the group can be found in a single clade, with no other species included in that clade. A group of taxa is polyphyletic if members of that group can be found in different clades, with other species intermixed. A group is paraphyletic if it includes a common ancestor and some, but not all, of the descendents. Taxa that branch together with no other species between them are called sister taxa (e.g. Anthozoan 1 and Anthozoan 2 from Fig. 2B). Sister-taxa are presumed to be more closely related to each other than to any other taxon on the tree. Similarly, clades that branch together are called sister clades. A species that branches at the base of a clade is considered basal to that clade (e.g. Anthozoan 3 is basal to Anthozoans 1 and 2 in Fig. 2B). A basal taxon is considered to be ancestral to that clade, having diverged from it before the other members of that clade. Conversely, a species that branches nearest the tips of the tree (e.g. Anthozoan 1), is considered to be a derived species, having diverged from the lineage more recently. Trees can be constructed to depict the amount of dissimilarity (= genetic distance) among taxa by branch lengths.

The horizontal branch lengths between any two taxa on a distance tree is proportional to the genetic distance between those taxa.

Three primary algorithms are typically used for analyzing sequence data, each with its own theoretical basis. The most common method is parsimony, which operates under the familiar tenet that the simplest explanation is the most likely. As it applies to phylogenetic analyses, the tree that requires the least number of evolutionary steps to explain the relationships of character states among the taxa involved is considered the most parsimonious reconstruction of those taxa. Parsimony analyses only consider similarities, and thus they are the most susceptible to the effects of convergent or parallel evolution.

A second suite of analyses are the distance methods. Distance analyses convert all information on sequence differences between two taxa to a single number, representative of the differences between those taxa. Various evolutionary models can be built into distance calculations, taking into consideration aspects such as variations in substitution rate and base frequencies. The actual sequence information is not retained once the distance calculation is made, which results in a loss of information. But the algorithm is relatively fast as a result, making it particularly useful for large data sets. Distance methods are not as accurate in finding the correct tree, however, if there are many short branches.

Maximum Likelihood (ML) methods have been developed most recently for practical use with sequence data sets. ML constructs phylogenetic trees that are the most likely given the sequence data being analyzed and the evolutionary model employed (Swofford et al. 1996, Huelsenbeck & Crandall 1997). The analysis produces a statistic for each tree, the maximum likelihood score (Lscore) that is the probability of that tree given the data set and the model. This score can be used to compare two different trees (i.e. two evolutionary hypotheses) statistically.

Maximum likelihood techniques allow one to tailor the evolutionary model used specifically for the analysis of each individual data set. This is especially important when

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working with large data sets, where the error introduced from using an incorrect method of analysis can overwhelm the phylogenetic information in the data set (DeSalle et al. 1994, Rzhetsky & Nei 1995).

The types of parameters ML can use in its evolutionary models include unequal base frequencies, base-specific rates of change (i.e. A to C, G to T, etc.), a proportion of sites that are invariant, and a variable substitution rate among the remaining sites. One can choose between having one, two, or six different rates of substitution. One rate of substitution effectively gives all sites the same mutational rate. Two substitutional rates allows the differentiation between transitions (A to G, C to T) and transversions (A to C, G to T). Six rates of substitution allows a rate of substitution for each possible base change (A to C, A to G, A to T, etc.,). Further heterogeneity in substitutional rate may be present in the data, especially in ribosomal sequences. The gamma distribution is often used to model this heterogeneity: a few sites have a high substitutional rate (potentially multiple substitutions at a single site), and the majority of sites have a very low substitutional rate. The exact shape of the gamma distribution is determined by the gamma parameter, α, which is the inverse of the coefficient of variation for the distribution. The most complex ML model incorporates all of the parameters just described (unequal base frequencies, six rates of substitution, a proportion of invariant sites, and rate heterogeneity modeled with a gamma distribution). This model is referred to as a General Time-Reversible model (GTR) with substitutional rate heterogeneity (discussed in depth in Swofford et al. 1996).

Maximum likelihood calculations will indicate which evolutionary parameters should be incorporated when analyzing a particular data set. The most accurate evolutionary model will always be the GTR model with rate heterogeneity, described above, but it is also the most complex (i.e. has the most parameters to calculate). It is not always necessary to use the most complex model. The simpler models incorporate fewer parameters (i.e. unequal base frequencies, proportion of invariant sites, etc.) and are

therefore less computer-intensive, and will run more quickly than the more complex models. A simpler method will also produce lower variance. A simpler model, however, may not be sufficiently accurate. In order to determine which model is the simplest for a given data set without sacrificing accuracy, a tree is generated from that data set with any of the standard models (parsimony, distance, etc.). The Lscores are then calculated for that tree using a number of different evolutionary models, and compared using the Likelihood Ratio Test (LRT) (Swofford et al. 1996, Huelsenbeck & Rannala 1997). The LRT will determine if a simpler model can be used, or if a more complex model will give significantly better results. Once the appropriate evolutionary model has been determined, the same initial tree is used to calculate the correct parameters for the model chosen based on the particular data set. Those parameters are then used in an ML analysis of the data.

Once the parameters have been chosen for a given data set, a search for the most likely tree is performed. The most thorough method of searching is termed an exhaustive search, in which all possible branching combinations of taxa are tried and evaluated. The number of possible trees increases geometrically with the number of taxa, however. Only one tree is possible with three taxa, but four taxa can yield 3 trees, five taxa yield 15 possible trees, six taxa generate 105 possible trees, etc. (Swofford 1991). A data set like those used for chapters 2 and 3 include over 50 taxa, which yield well over 3×10^{74} possible trees. Computationally, this is very intensive. As a result, I have conducted heuristic searches of my data sets.

Heuristic searches are must faster than exhaustive searches, but they are not guaranteed to find the optimal tree. Heuristic searches are conducted by constructing an initial tree, and then swapping branches on that tree in an attempt to improve the tree. The search will settle on the best tree possible given the original starting tree. This type of searching runs the risk of finding a 'locally optimal' tree rather than a 'globally optimal' tree. The best way to increase the chances of finding the globally optimal tree is to perform

multiple heuristic searches, with different starting trees. This is what I have done for the bulk of my data analyses.

Once the most likely tree (or trees) have been determined, manipulations of those trees can yield valuable information about the strengths and weaknesses of the phylogenetic signal. The 'most likely' tree is indeed most likely, but it may not be statistically worse than a tree with an alternate topology. I used the computer program PAUP* (Swofford 1996 betatest version) in conjunction with the tree-building program MacClade (Maddison & Maddison 1992) throughout my thesis work to build phylogenetic trees and test their topologies. The simplest way to test alternate evolutionary hypotheses is to construct trees in MacClade, and then measure the Lscores of both trees in PAUP* using the appropriate evolutionary model. The Kishino-Hasegawa test (KH Test) (Kishino & Hasegawa 1989) within PAUP* is a two-tailed statistical test to determine if one tree is statistically less likely than the other.

PAUP* offers two methods that I used for testing the topological support for phylogenetic trees. The first is a search where a portion of a tree is constrained. I used constrained searches to test the branching order for the primary clades in my trees: I constrained the topology within each of the clades, then performed a search and kept every tree that was constructed. The KH Test can then determine if one branching pattern is better than the others, and if alternate branching patterns are significantly less likely than the best.

The backbone search is another type of constraint, and will determine where a given taxon can branch on a tree without significantly reducing the likelihood of the tree. Some taxa will fall in a single position on the most likely tree, but the tree may not be much less likely if the taxa are placed in a different position. The backbone search is a simple way to test all possible positions for a given taxon without creating and testing each tree individually. The entire tree is constrained for this search as a backbone, minus the taxon

being tested. An exhaustive search is conducted and all trees are saved. The KH Test will show which branching positions are not significantly less likely than the optimal position.

Specific Issues for this Project

Museum Specimens

Museum collections contain a wealth of information for both morphologists and geneticists (Thomas 1994). These collections have been assembled over the last few centuries, and contain species that are rare, not easily accessible, or even extinct. Museum collections constitute an invaluable resource for countless research questions.

The use of museum specimens for genetic analyses has inherent difficulties, relating primarily to the degraded nature of archival DNA. Despite fixation, DNA continues to degrade over time. Archival DNA is damaged primarily by oxidation and hydrolysis (Lindahl 1993). Oxidation of the pyrimidines (cytosine and thymidine) is the primary complication for PCR reactions (Hoss et al. 1996). As a result of this damage, only small stretches of DNA can be PCR amplified from most museum specimens.

The traditional method of preservation for museum specimens is formalin. Formalin preserves tissue by crosslinking DNA and proteins to themselves and each other (Fox et al. 1985) which is highly effective for the preservation of archival specimens. The same cross-linking creates hydroxymethyl groups on the DNA, which interfere with the PCR process. Additionally, much of the DNA remains tightly bound to proteins and is lost through the DNA extraction procedure (Shedlock et al. 1997). PCR and sequencing reactions can be successfully performed on formalin-fixed tissues, but they require special handling and only small regions of DNA (50-500 bp) can be amplified (France & Kocher 1996, Shedlock et al. 1997).

Octocorals have traditionally been preserved in ethanol, rather than formalin, because the formalin dissolves the calcium spicules which are used in species identification.

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The absence of formalin increases the feasibility of determining longer sequences from museum octocoral specimens. DNA extractions on recently ethanol-preserved specimens are relatively straightforward (Kocher 1992), and I was able to extract and PCR-amplify DNA from specimens that had been preserved up to 50 years. Chapter 2 describes the protocol I used with the alcohol-preserved specimens.

Most of the museum specimens for which I attempted PCR reactions yielded no PCR product after an initial PCR reaction. In order to generate sufficient PCR product for the sequencing process, I had to perform PCR reamplifications for several specimens: an initial PCR amplification was performed, and an aliquot of the first reaction was used as the template for a second round of PCR. The negative control from the initial PCR reaction was always included as the template for a negative control for the second PCR reaction. Even using PCR reamplifications, I was only able to amplify the entire 18S gene in one piece for one specimen. Several specimens were amplified in two or three pieces to generate the entire 18S sequence.

The degraded nature of the archival DNA, as well as the multiple rounds of PCR performed on each specimen, increases the likelihood that contaminant DNA rather than the target DNA will be amplified. PCR preferentially amplifies molecules of DNA that are intact, so a contaminant of recent origin (i.e. introduced to the specimen after it was preserved) may be more likely amplified than the older, sample DNA. One way to increase the chances of amplifying the target DNA is to design taxon-specific PCR primers. I designed a suite of primers that matched the DNA of octocoral specimens for which I knew the sequences, but not the DNA of fungi, symbionts, or other phyla of organisms that might be found as contaminants. All sequences were compared to the GenBank database after they were determined, to verify that they were most similar to other cnidarians and not a potential non-Cnidarian contaminant.

Pseudogenes

An additional difficulty I encountered during this thesis work, probably relating to the degraded nature of the museum specimens, was the amplification of pseudogenes rather than the target 18S gene. Normally, the multiple copies of the ribosomal genes found within each cell are assumed to be identical, resulting theoretically from concerted evolution (Hillis & Dixon 1991). Pseudogenes are copies of ribosomal genes that are not identical to the majority, and are also not transcribed. They are similar to the functional ribosomal gene but are not functional themselves, and as a result, evolve neutrally. Pseudogenes have been found in several invertebrate taxa, and have diverged from the functional copy of the ribosomal gene. Pseudogenes found in the flatworm *Dugesia* were approximately 8% different from the transcribed copies of the 18S gene, which approaches the divergence found between families for this group (Carranza et al. 1996). This level of divergence corresponds to the divergence found between classes and subclasses of anthozoans (discussed in Chapter 3). Seven of the sequences that I determined from museum specimens were most likely sequences of pseudogenes rather than the functional nuclear 18S rRNA gene. All of these putative pseudogenes clustered together in my analyses, and they branched most closely with the Order Scleractinia (Subclass Hexacorallia) rather than the Octocorallia to which they belonged. These specimens were excluded from my analyses.

I encountered pseudogene sequences in determining the sequence for *Dendrobrachia paucispina*. The specimen had been alcohol-preserved for eight years, and two PCR fragments (with a 1065-bp overlap) were required to construct the entire 18S sequence. The sequences were determined for four clones of each fragment. The clones for the first half were all identical, but the clones for the second half were all different. Each of the four clones were verified as cnidarian by a search of the GenBank database, but only one of the sequences was identical to the first half of the gene, based on an

overlapping region of the two sequences. I used the clone that was identical to the first half to complete the *Dendrobrachia* sequence, and hypothesized that the other sequences were from pseudogenes. The complete sequence placed *Dendrobrachia* within the Octocorallia, as expected from morphology, and not with the cluster of pseudogenes near the Scleractinia. I am therefore relatively confident that the sequence for *Dendrobrachia* is real, and not an artifact. Sequences from additional specimens of *Dendrobrachia* would be necessary to verify the validity of the sequence I have generated.

Previous Molecular Studies

Molecular studies of the Anthozoa are few, but they have given us some insight into the questions I address with this thesis. These studies have examined a variety of ribosomal genes, including the mitochondrial 16S rRNA gene (France et al. 1996), the nuclear 28S rRNA gene (Chen et al. 1995), and the nuclear 18S gene (Song & Won 1997). They examine the subclass divisions within the Anthozoa and the ordinal divisions within the Hexacorallia and the Octocorallia, but do not address the phylogenetic affinities of *Dactylanthus* or *Dendrobrachia*. All of these studies used general parsimony or distance methods rather than the more accurate maximum likelihood methods. None of these studies have the breadth of taxonomic sampling that this study does, and all of them use partial gene sequences. But these studies offer both support for, and alternate hypotheses to, what I have found in my thesis work.

Mitochondrial 16S (France et al. 1996) and nuclear 18S (Song & Won 1997) sequence information have both indicated that the Ceriantharia and the Antipatharia, united within the Subclass Ceriantipatharia, are genetically divergent from one another. The nuclear 18S analyses indicated that the Ceriantharia are ancestral to all other Anthozoa, and the Antipatharia have affinities within the Hexacorallia. Mitochondrial DNA supported that the Antipatharia branch within the Hexacorallia, but indicated that the Ceriantharia were

ancestral to the Hexacorallia rather than the entire Anthozoa. Neither study had complete taxonomic representation of the orders in the Hexacorallia to determine the specific affinities of the Antipatharia. My thesis work included representatives of all of the orders within the Hexacorallia, and therefore I could generate a more complete analysis of the subclass divisions within the Anthozoa.

The ordinal-level divisions within the Hexacorallia are supported by mitochondrial rDNA (France et al. 1996) and 18S rDNA (Song & Won 1997), but not entirely by 28S rDNA (Chen et al. 1995). The Scleractinia were monophyletic in Chen et al.'s analyses, but both the Actiniaria and Corallimorpharia were polyphyletic. Chen et al. used very short sequences, however, which may have affected the results they found. I have included over 1600 bp of sequence information spanning the entire 18S rRNA gene for my analyses.

Molecular information is not as available for addressing the divisions within the Octocorallia. The France et al. study (1996) is the most thorough so far, including representatives from the Pennatulacea, and 16 species from 10 families within the Alcyonacea. Mitochondrial DNA sequences do not indicate a correlation between phylogenetic structure and traditional taxonomy within the Octocorallia. The analyses of Song and Won (1997) did not disagree with the current taxonomy, but they include only a single pennatulacean and four species from two families of the Alcyonacea. Both studies did, however, find the Pennatulacea to be ancestral within the Octocorallia. My thesis project continues this work, including representatives of 22 families within the Order Alcyonacea, a representative of the Order Helioporacea, and eight representatives of the Order Pennatulacea.

Summary

The goal of this thesis project was to build the most complete molecular phylogeny of the Anthozoa to date. A number of specific questions were addressed with this work, relating to the taxonomic divisions within the Class Anthozoa, and within the subclasses Hexacorallia, Octocorallia, and Ceriantipatharia:

- Does genetic information support division of the Class Anthozoa into two subclasses or three? Is the association of the Ceriantharia and the Antipatharia in the Subclass Ceriantipatharia valid, based on evolutionary history?
- Does genetic sequence information support the division of the Subclass Octocorallia into three orders or seven? Do the traditional morphological divisions correspond to the phylogenetic divisions I find?
- Are the Ptychodactiaria deserving of ordinal distinction separate from the Actiniaria within the Hexacorallia?
- Is *Dendrobrachia* affiliated with the Antipatharia, with which it was previously classified? Or is it more closely related to the Octocorallia, as indicated by polyp morphology?
- Which morphological characters appear to provide evolutionary information? Which characters clearly do not?

In order to address these questions, I determined the nuclear 18S rDNA sequences from 58 species across the Class Anthozoa. I included 12 previously sequenced anthozoans, available from the GenBank database, as well. This sampling scheme gave me representatives from across the morphological breadth of the entire class. I used the complete 18S sequence, and conducted my phylogenetic analyses using maximum likelihood techniques. ML allowed me to tailor the evolutionary model I used to be

appropriate for this particular gene and this group of species. I also used ML techniques to compare alternate evolutionary hypotheses statistically, and thereby test hypotheses suggested in previous molecular studies.

This thesis project further developed techniques for utilizing ethanol-preserved museum specimens for DNA sequence analyses. DNA extraction and PCR amplification of recently-preserved (i.e. 1-2 years) specimens is routinely practiced in many laboratories, but this is not true for long-preserved (i.e. 10-50 years) specimens. DNA can be successfully extracted and PCR amplified from recently preserved specimens, but archival specimens require special handling and protocols. Chapter 2 describes the techniques that were successful for determining DNA sequences from museum specimens of octocorals.

Knowledge of how species evolve is essential to our understanding of the natural world. The species that are on the Earth today are the direct result of millions of years of evolutionary change, and that evolution is continuing. The taxonomic divisions within the Anthozoa are difficult to determine using only morphological characters, as anthozoans are some of the simplest invertebrate species. The addition of molecular characters gives us a common character to compare across all species within the class, and which can also be compared to other invertebrate taxa.

Anthozoans are a very important group of taxa from an ecological view. Species of anthozoans can be found everywhere throughout the ocean, from the shallow intertidal to the deep sea. Species in the Order Scleractinia create the foundation for the coral reef ecosystem, which is highly complex and very fragile. Members of both the Subclass Octocorallia and Hexacorallia are also prominent on reef ecosystems. A better understanding of how these species are related to each other and how they change over time may help us conserve these delicate environments for years to come.

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Chapter 2

Generating DNA sequence information from museum collections of octocoral specimens (Phylum Cnidaria: Class Anthozoa)

Abstract

Museum collections of preserved flora and fauna historically used for morphological studies are now increasingly being utilized for addressing genetic questions. The extraction of DNA from ethanol-preserved specimens of recent origin is practiced routinely, but genetic analyses of long-preserved specimens have inherent difficulties due to the slow degradation of DNA. The goal of this study was to demonstrate the feasibility of isolating genomic DNA from museum specimens of octocorals with subsequent amplification of the 18S rRNA gene. Techniques were designed to solve several problems for obtaining genetic sequences from museum specimens. The DNA extractions of museum specimens yielded only small amounts of DNA of very low molecular weight, which limits the length of Polymerase Chain Reaction (PCR) products that can be generated with standard protocols. I was successful in producing PCR fragments from museum specimens by performing an extended tissue digestion on the archival specimens, running an initial PCR reaction, and then following with a reamplification of the original PCR product. The use of taxon-specific PCR primers decreased the risk of amplifying contaminant DNA rather than the target DNA in archival specimens. The combination of our modified extraction protocol and PCR reamplifications with taxon-specific PCR primers allowed me to generate 700- to 1800-basepair sequences from 16 specimens from three different museum collections that had been preserved for up to fifty years.

Introduction

Scientists and lay persons have contributed specimens to museum collections world-wide for well over one hundred years, creating a highly useful resource for investigators today. Many of these specimens have been collected during expeditions, while others have been collected incidentally in the course of other pursuits. These preserved specimens can be used to address a variety of questions.

Museum collections have been, and continue to be, used extensively for morphological studies, but development of techniques utilizing the Polymerase Chain Reaction (PCR) have increased the potential value of museum collections for investigating genetic questions. The molecular analysis of archival specimens can lend insight not only into evolutionary or phylogenetic investigations among taxa, but also for questions of gene flow within species. Changes in allelic frequencies can be traced through time or across geographic areas (Kocher 1992, Thomas 1994). Such allelic changes may indicate levels of genetic variation within species, changes in genetic variation over time, hybridization events between species, or range expansions or contractions. Museum specimens can also supply genetic information for species that have recently become extinct or are currently endangered (Thomas 1994).

Extracted DNA from fresh or frozen tissue is of considerably higher molecular weight compared to that from preserved specimens. Therefore, genetic analyses are easier to conduct using fresh or frozen tissue; however, the use of preserved specimens is preferable in many cases. Collection of fresh samples from rare species or those with small population sizes is usually inappropriate or impossible. Many species live in remote habitats that are highly inaccessible, and require great expense for sample collection. The use of existing collections in these cases are preferable to the acquisition of new specimens (France and Kocher 1996).

Museum specimens have been subjected to variable handling and preservation techniques. The type of preservative used, the speed with which a sample is preserved, and the subsequent methods by which a sample is handled will have a large effect on the resulting condition of the DNA. The handling will determine, in part, the utility of a specimen for a given research question. Cryogenic preservation is often preferable for genetic studies as liquid nitrogen maximizes DNA extraction yields. Liquid nitrogen, however, was not available historically, and currently is not always available in all localities or field conditions. A number of alternative preservation techniques have been employed, including drying, the use of various alcohols, formaldehyde, mannitol-sucrose buffer with EDTA, and guanidine hydrochloride (Dessauer et al. 1996).

Most museum specimens have been dried or preserved in formalin and the latter transferred to ethanol for long-term storage. Formalin preservation cross-links molecules of proteins and nucleic acids to themselves and to each other (Fox et al. 1985). Hydroxymethyl groups are also formed on the DNA molecules (Chang and Loew 1994). The tight crosslinking of DNA to proteins is problematic for DNA extraction procedures, as much of the DNA is thereby lost into the organic phase of the phenol extraction procedure (Shedlock et al. 1997). The methylation can interfere with PCR replication by impeding primer annealing as well as derailing the DNA polymerase during the extension phase (Karlsen et al. 1994). Protocols have been developed for successfully obtaining sequence from formalin-preserved specimens, in which the preserved specimen is soaked in buffer followed by extended periods of digestion with proteinase K which permits the DNA to dissociate from the protein complexes. PCR replication of formalin-fixed tissues remains difficult, however, and PCR amplification is only possible for short (i.e. 50-300 bp, and rarely 500-600 bp) stretches of formalin-fixed DNA (France and Kocher 1996; Shedlock et al. 1997).

Museum collections of octocoral specimens are unusual in that they are often preserved initially in ethanol rather than formalin, because formalin dissolves the calcareous spicules that are used in species identification. The decreased likelihood of the use of formalin in the preservation and storage of octocorals increases the feasibility of the DNA isolation process greatly. The extraction of DNA from recently (i.e. a few months or years) ethanol-preserved specimens is now practiced routinely in a number of laboratories (e.g. Smith et al. 1987; Kawasaki 1990; Meyer et al. 1990; Wheeler et al. 1993). Unlike formalin, ethanol does not cross-link proteins, but it is less efficient as a tissue preservative. Several studies have documented the degradation of DNA over time in ethanol-preserved specimens (e.g. Post et al. 1993; Flournoy et al. 1996). Specimens stored in ethanol at lower temperatures tend to preserve better (Post et al. 1993; Hoss et al. 1996), and PCR amplifications of shorter lengths of DNA are typically more successful than longer lengths in older samples. Very few studies have been published based on obtaining genetic information from specimens preserved in ethanol for longer than a few years.

Genetic analyses of long-preserved specimens have inherent difficulties, due to the slow degradation of DNA in the presence of a fixative. The DNA damage that occurs in preserved samples is primarily due to oxidation and hydrolysis (Lindahl 1993). The damage that is the most detrimental to the performance of genetic analyses includes modifications to the pyrimidines, cross-linking between molecules, and missing bases (Paabo 1989). Oxidative modifications to purines, however, do not seem to affect the ability to generate sequences from preserved materials (Hoss et al. 1996). These types of modifications will particularly hinder the successful direct cloning of ancient DNA, because damaged DNA will not be copied by the bacterial replicative process. In the event that cloning is successful, however, often the bacterial replication process will repair any damage it perceives, thereby introducing error into the sequence (Paabo et al. 1989).

PCR is also hindered by damaged DNA, but offers two unique advantages when working with ancient DNA. First, the PCR will preferentially amplify the DNA molecules that remain intact, because the DNA polymerase will move more slowly over damaged regions (Paabo et al. 1989). Additionally, any modified DNA strand that is replicated will be unlikely to have a sizable effect on the resulting genetic sequence unless it is replicated early in the PCR process. If a damaged strand does get replicated early on, however, the genetic sequence that results will be influenced more substantially by those damaged regions.

Another difficulty in using archival specimens for genetic analysis is the increased possibility that contaminating DNA will amplify rather than the target DNA, which may be degraded and in low concentrations (Paabo 1990). The amplification of contaminating DNA is rarely a significant problem when using fresh or frozen tissue, as fresh DNA extractions yield large quantities of non-degraded DNA, and concentration of the target DNA usually far exceeds any that of any contaminating DNA. Museum specimens may contain trace DNA not only from symbionts or epibionts, fungi and bacteria, which can be introduced both before or after preservation. Contaminating DNA of modern origin will likely be less degraded than the ancient target DNA, and may be more readily amplified in the PCR process. Even if the contaminating DNA is degraded, there is still a chance it will be amplified instead of, or along with, the target DNA. Extreme caution must be taken when working with archival specimens to avoid amplifying contaminant DNA. One method which can be effective in eliminating the amplification of contaminating DNA is the use of taxon-specific PCR primers. Specific primers are designed using regions of the target DNA that are characteristic of the target but not of potential contaminants. A well-designed specific primer will preferentially amplify the target DNA to the exclusion of extraneous DNA.

Complete sequences for the 18S rRNA gene were desired for a companion study on the phylogeny of the Class Anthozoa, and in particular the Subclass Octocorallia (Berntson et al. in prep). Because many of the specimens for this study had been preserved for up to fifty years and their DNA was potentially highly degraded, standard DNA extraction and PCR techniques proved unsuccessful. Museum collections were essential to this phylogeny project as many octocoral species, including entire families, are found exclusively in the deep sea. Fresh specimens of these species are accessible only by submersibles or dredging, and it was not feasible to collect new specimens of all the necessary species.

There were two primary goals of this study: 1) to develop a technique for the isolation of DNA from preserved material, yielding as large quantities of nondegraded DNA as possible, and 2) to PCR amplify the 18S rRNA gene from the isolated genomic DNA in fragments greater than 500 bp in length, with the ultimate purpose of determining the DNA sequence of the complete 18S rRNA gene from the preserved octocoral specimens. The use of a modified DNA extraction protocol combined with taxon-specific PCR primers described herein have allowed us to accomplish these goals.

Methods

Specimens

Specimens for this study were acquired from Dr. Frederick Bayer of the National Museum of Natural History, Dr. Wolfgang Sterrer of the Bermuda Aquarium, Natural History Museum and Zoo, and Ardis Johnston of the Harvard Museum for Comparative Zoology. These specimens had been stored in ethanol for periods ranging from two to 50 years.

DNA Extraction Protocol

The extraction protocols I used was similar to those described by Coffroth et al. (1992) and Winnepenninckx et al. (1993). My deviations from their protocols consisted primarily of a lower temperature and longer duration for the proteinase K digestion. The extraction buffer included 1.4M NaCl, 0.02M EDTA, 0.1M Tris-HCl (pH 8.0), 2% cetyltrimethylammonium bromide (CTAB) (Sigma Chemical Co.), and 0.2% beta-mercaptoethanol (Sigma Chemical Co.). This buffer is particularly effective at removing polysaccharides that are abundant in coral tissues, and which can interfere with DNA extraction. General CTAB-based protocols have been described for use with a variety of invertebrate taxa, including algae, molluscs, ctenophores, and brachiopods (Karl and Bailiff 1989; Shivji, Rogers et al. 1992; Winnepenninckx, Backeljau et al. 1993).

Five to ten polyps of the ethanol-preserved octocorals were placed on ice in two to ten mls 2X CTAB buffer for two to 24 hours, with the buffer replaced several times during this period. The buffer was removed, and the tissue minced finely with a razor blade and placed in a 1.5-ml eppendorf tube with 300 µl of 2X CTAB buffer. A plastic dounce was employed to further shear the tissue, and an additional 300 µl of 2X CTAB was added. The samples were placed at 55°C and digested with 5 µl of proteinase K (at 20 mg/ml) for approximately 24 hours, with periodic agitation. Another 5 µl of proteinase K was added, and the tissues continued to digest for an additional eight to twelve hours. The tissues were extracted once with an equal volume of 24:1 chloroform:isoamyl alcohol, and precipitated in two volumes of cold 95% ethanol at -20°C overnight. The tubes were centrifuged at 10,000xg for 30 minutes, and the ethanol was removed. The pellets were washed with 500 µl cold 70% ethanol, and the tubes were centrifuged at 7,000xg for 15 minutes. The ethanol was removed, and the pellets dried at room temperature. The pellets were resuspended in 50 µl of TE buffer and placed at 4°C for three to four hours before visualization on an agarose gel.

DNA Amplification Protocols

Pipet tips with a filter barrier were used throughout this process to guard against contamination of the reactions. Negative controls were included during the DNA extractions and PCR reactions to detect contamination if it did occur. Each extracted DNA sample was diluted 1:10 in TE buffer (10 mM Tris-HCl--pH 8.0, 1 mM EDTA--pH 8.0), and 2 µl of that dilution was used in a 50-µl PCR reaction. Modified versions of the universal eukaryotic primers A and B from Medlin et al. (1988) (Table 1) were used in the initial DNA amplifications of the 18S rRNA gene. These primers amplify the entire anthozoan nuclear 18S rRNA gene, a fragment which we found to be approximately 1800 bp in length in anthozoans. Thirty-five cycles of PCR were carried out in a Perkin-Elmer Thermocycler 480. The DNA was denatured at 94°C for 45 seconds, the primers and template were annealed at 55°C for one minute, and the original DNA strand was extended at 72°C for 90 seconds. These cycles were followed by a five-minute extension at 72°C. The product was run on a 1% agarose gel. If there was a visible product, that product was prepared for TA-cloning.

For those specimens with no visible product, a second PCR reaction was conducted using 1 µl of product from the initial PCR reaction as the template. The amplified negative control (no DNA was added) from the initial PCR reaction was included in the second reaction as well, using 1 µl of the original negative control as template. The primers used for the second PCR reaction were chosen from those listed in Table 1, with at least one primer falling internally to the initial A and B primers. The internal primers were selected from a combination of universal eukaryotic primers and a set of octocoral-specific primers that were designed by us (Table 1). The octocoral-specific primers were designed to amplify anthozoan DNA, but not DNA from potential contaminants. The octocoral-specific primers were designed from alignments of Genbank sequences of actiniarians (*Anemonia sulcata*, Genbank accession #X53498, and *Anthopleura kurogane*, accession #Z21671),

Table 1   PCR primers used for primary and secondary amplifications of
              DNA from octocoral specimens.   The octocoral-specific
              primers were designed for phylogenetic studies of the Subclass
              Octocorallia (described in Berntson et al. in prep.).   Primer
              numbers refer to position in prokaryotic small-subunit
              ribosomal DNA.

Primer	Specificity	Sequence	Reference
A (F)*	Univ. Euk.	5' AACCTGGTTGATCCTGCCAGT 3'	Medlin et al. (1988)
B (R)**	Univ. Euk.	5' TGATCCTTCTGCAGGTTCACCTAC 3'	Medlin et al. (1988)
514F	Univ. Euk.	5' GTGCCAGCMGCCGCGG 3'	Elwood et al. (1985)
536R	Univ. Euk.	5' WATTACCGCGGCKGCTG 3'	Lane et al. (1985)
1055F	Univ. Euk.	5' GGTGGTGCATGGCCG 3'	Elwood et al. (1985)
1055R	Univ. Euk.	5' CGGCCATGCACCACC 3'	Elwood et al. (1985)
373F	Univ. Euk.	5' GATTCCGGAGAGGGAGCCT 3'	Weekers et al. (1994)
1200R	Univ. Euk.	5' GGGCATCACAGACCTG 3'	Weekers et al. (1994)
705F	Octocoral	5' GGTCAGCCGTAAGGTTT 3'	present study
705R	Octocoral	5' CATACCTTCGGGCTGACC 3'	present study
900F	Octocoral	5' GTTGGTTTTTGAACCGAAG 3'	present study
900R	Euk.	5' CTTCGGTTCTAGAAACCAAC 3'	present study
1560R	Octocoral	5' GGTGAAGGAGTTACTCGATG 3'	present study

*F sequences prime in the 5' -> 3' direction
**R sequences prime in the 3' -> 5' direction

two fungi (*Cryptococcus neoformans*, accession #L05428, and *Bullera unica*, accession #D78330), potential epibionts from Mollusca and Crustacea (*Mytilus galloprovincialis*, accession #L33451, and *Stenocypris major*, accession #Z22850), and a zooxanthella symbiont (*Symbiodinium* sp., accession #M88509). Octocoral sequences derived from frozen tissue in this lab (*Renilla reniformis* accession #AF052581, *Narella nuttingi* accession #AF052882, and *Anthomastus* sp. accession #AF052881) were verified as cnidarian through a BLAST search of GenBank and were also used in the primer design. Final DNA sequences were verified as cnidarian by a BLAST search of Genbank.

The specific primer pair combinations were selected to 1) amplify the largest region of the 18S gene possible for each specimen, and 2) include at least one octocoral-specific primer for one of the PCR reactions, reducing the probability of amplifying contaminating DNA. A diagram of the PCR primers used can be found in Fig. 1. If the initial PCR attempts were unsuccessful using primers A and B, a reamplification using internal primers was performed. If this was unsuccessful as well, I began anew with the initial 1:10 diluted DNA extract, and used PCR primers flanking a smaller genomic region. For example, an initial amplification would target the region flanked by primers A and 705R, and then the re-amplification would use primers A and 536R. The smallest fragment attempted for DNA sequence determination was approximately one third of the entire gene.

DNA Cloning and Sequencing Protocols

The final PCR product was cloned using the Original TA Cloning Kit (Invitrogen Corporation). The PCR product was ligated into the pCR 2.1 cloning vector, then transformed into a strain of INVαF' cells following the manufacturer's protocol. The plasmid DNA was isolated from individual clones using the Wizard Miniprep DNA Purification Kit (Promega Corporation) and subsequently used as a template for a cycle sequencing reaction, using the SequiTherm EXCEL Long-Read DNA Sequencing Kit-LC
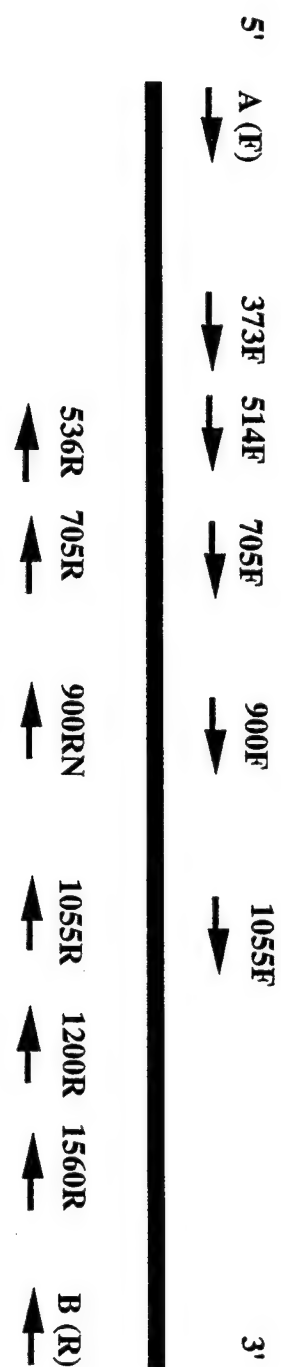
Fig. 1   Position and orientation of 18S rDNA primers used in PCR amplifications.

(Epicentre Technologies). Sequences were determined for both the forward and reverse strands of the gene. The reactions were run on a LI-COR 4000 DNA Sequencer, using the infrared-labeled primers shown in Table 2. The resulting images were interpreted using the BioImage gel reader program.

Negative Controls

I performed several controls throughout my work to detect any potential contamination. A negative extraction (no tissue added) was performed with the DNA extraction protocol. Negative controls (no DNA template added) were included with each primary and secondary PCR reaction. As one additional control, one frozen specimen and one ethanol-preserved specimen were chosen for re-extraction and re-determination of the DNA sequence to verify our ability to replicate the complete process. In each case, I found very good internal consistency. There were no sequence differences between the replicates for the frozen specimen (*Protoptilum* sp.), and there was a 0.11% error rate, corresponding to 2 base changes over 1800 bp total for the ethanol-preserved specimen (*Umbellula* sp. USNM 54597) (Table 4).

Results

DNA extractions from tissues of ethanol-preserved museum specimens typically yielded small amounts of DNA that could rarely be detected on an agarose gel (Fig. 2, lanes 4 and 5). If DNA could be detected, it was of lower molecular weight than extractions of fresh tissue (Fig. 2, lane 3). My initial PCR amplification of the 1800-bp 18S rRNA gene from these extractions likewise did not yield visible product in the majority of museum specimens I examined. In some instances I was successful in amplifying smaller fragments (700-1200 bp) in a single PCR amplification. For the remainder of specimens for which a

Primer	Sequence
M13F*	5' CACGACGTTGTAAAACGAC 3'
M13R**	5' GAATAACAATTTCACACAGG 3'
A (F)	5' ACCTGGTTGATCCTGCC 3'
B (R)	5' CTTCTGCAGGTTCACCTAC 3'
514F	5' TCTGGTGCCAGCASCCGCGG 3'
536R	5' TGGWATTACCGCGGSTGCTG 3'
1055F	5' GTGGTGGTGCATGGCCG 3'
1055R	5' AAGAACGGCCATGCACCAC 3'

*F sequences prime in the 5' -> 3' direction

**R sequences prime in the 3' -> 5' direction

Table 2   **Infrared-labeled primers used with the Licor sequencer. Primer numbers refer to position in prokaryotic small-subunit ribosomal DNA.**
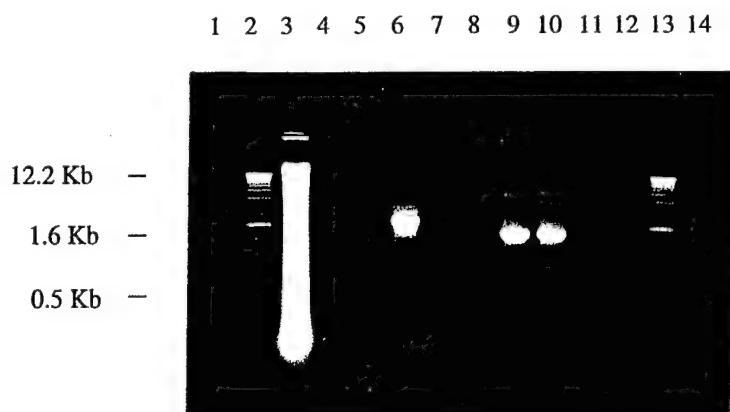
Fig. 2 Products of DNA extractions of museum specimens, initial PCR reactions, and secondary PCR reactions. Lanes are as follows: 1) blank; 2) 1-Kb ladder (Gibco BRL); 3) 5 µl of *Palythoa variabilis* DNA extraction, tissue frozen; 4) 5 µl of *Dendrobrachia paucispina* DNA extraction, tissue preserved in ethanol 8 years; 5) 5 µl of *Nidalia occidentalis* DNA extraction, tissue preserved in ethanol 13 years; 6) Initial PCR reaction of *Palythoa variabilis* with primers A and B; 7) Initial PCR reaction of *D. paucispina* with primers A and B; 8) Initial PCR reaction of *N. occidentalis* with primers A and B; 9) Secondary PCR reaction of *D. paucispina* with primers A and 1200R; 10) Secondary PCR reaction of *N. occidentalis* with primers A and 1200R; 11) Secondary PCR reaction of negative control from primary PCR reaction, with primers A and 1200R; 12) Negative control from secondary PCR reaction with primers A and 1200R; 13) 1-Kb ladder (Gibco BRL); 14) blank.

single PCR reaction was unsuccessful, I performed a second PCR reaction using internal primers and the first PCR product as template (Fig. 2). The smallest fragment size I chose to amplify ranged from 500 to 700 bp.

The quality of DNA extracted from different museum specimens was evaluated based on the intensity of the DNA fragment as visualized on an agarose gel stained with ethidium bromide. This quality was highly variable, with no apparent correlation between the length of PCR product produced and the length of preservation time. I amplified 700-bp fragments from one specimen that had been preserved for 50 years, but was unable to amplify the same fragment from a specimen that had been preserved for nine years. Table 3 summarizes the results of DNA extractions and amplifications from the museum specimens. I did not perform PCR reamplifications on all samples, as I concentrated on those species I deemed phylogenetically important for our objectives. Archival specimens of those species for which fresh or recently preserved tissue became available were abandoned if PCR products were not readily produced. The variable success rate that I experienced in producing PCR products may have resulted from inconsistent handling of the specimens at the time of collection. This inconsistency may include preservation in formalin with subsequent transfer to alcohol. Such information is not always available for museum specimens.

I noted occasional nucleotide sequence variation within an individual specimen, both in overlapping regions of fragments produced in different PCR reactions and in pooled clones from the same PCR reaction. These base differences were found in most, but not in every one of the museum specimens (13 out of 15). The base differences I found consisted of simple substitutions, with only one instance of an insertion (four bp in *Dendrobrachia paucispina*). The resulting error was low (Table 4), usually less than 1%. This rate of error would apply to the remainder of the gene proportionally, not just to the

Table 3   Summary of results from all museum specimens. Specimens
are from the National Museum of Natural History collections
unless otherwise noted. Those specimens for which DNA
sequences were generated are listed with the primer pairs used
for the amplification reactions. Multiple primer pairs were
used for those specimens that could not be amplified in one
piece. If contaminant sequences were generated, the type of
contaminant is identified. Specimens that yielded only
contaminant sequences are noted with an asterisk. The
specimens that did not generate sequences are also listed.
PCR reamplifications were not attempted on all specimens as I
concentrated on those species of greatest phylogenetic
importance to my study. The most stringent attempt made for
each specimen is noted.

a: Harvard Museum of Comparative Zoology
b: Bermuda Aquarium, Natural History Museum and Zoo
c: Specimen was dried.
d: Specimen was abandoned when alternate specimens
became available.
e: Sequence produced was a pseudogene or chimera.

Species	Specimen #	Date Preserved	Cnidarian Sequences Generated	Initial PCR Amplifications	PCR Reamplifications Not Required (N/R)	Contaminant Found
Tubipora musica	USNM 79459	1947	yes	A/536R, 514F/1055R 1055F/B		algal
Carijoa riisei	USNM 49691	1950	no[d]			
Heliopora coerulea	not cataloged	1953	no*			fungal/cnidarian
Ifalukella yanii	USNM 51521	1953	no*			fungal/cnidarian
Pachyclavularia violacea	USNM 79630	1953	no	A/536R		
Briareum stechei	USNM 50857	1954	no	A/B	900F/B	
Clavularia koellikeri	USNM 75090	1955	no	A/536R		
Umbellula sp.	USNM 97918	1961	no	A/B	900F/B	
Keroeides koreni	USNM 83605	1964	no	A/705R	A/536R	
Eunicella albatrossi	USNM 57212	1965	no	A/536R		
Keratoisis sp.	USNM 57283	1965	no[d]			
Rhodellinda gardineri	USNM 60217	1965	no	A/1200R	A/536R	
Alcyonium palmatum	USNM 57131	1967	no	A/536R		
Bellonella rubristella	USNM 55382	1968	no*			algal/fungal
Siphonogorgia sp.	USNM 55582	1968	yes			fungal[e]
Solenopodium sp.	USNM 55664	1968	no[d]			fungal
Chrysogorgia spiculosa	USNM 52854	1969	no*			fungal
Thelogorgia stellata	USNM 55443	1970	no*			fungal
Riisea paniculata	USNM 93934	1971	yes	A/1200	A/536R	fungal
Umbellula sp.	USNM 54656	1971	yes	A/B	A/900R, 900F/B	
Stephanogorgia wainwrighti	USNM 54056	1972	no[d]			
Umbellula sp.*	N/A	1972	yes	A/B	900F/B	
Bellonella indica	USNM 58498	1973	no[d]			
Melithaea ochracea	USNM 58590	1973	no	A/536R		
Siphonogorgia (Chironephthya) sp.	USNM 58584	1973	yes	A/900R, 705F/1200R 900F/B	A/705R, 705F/1055R 900F/B	
Siphonogorgia godeffroyi	USNM 58581	1973	no	A/705R	A/536R	
Umbellula thomsonii	USNM 58994	1973	no	A/B	900F/B	
Taiaroa tauhou	USNM 54271	1974	yes	A/536R, 514F/1055R 1055F/B	N/R	
Umbellula sp.	USNM 54597	1974	yes	A/B	N/R	fungal
Acanthogorgia armata	USNM 55837	1975	no*			fungal
Australisis sarmentosa	USNM 78370	1975	no*			fungal/protozoan
Briareum asbestinum	USNM 59051	1975	no	A/536R		
Renilla reniformis	USNM 57404	1975	no	A/536R		
Stereonephthya unicolor	USNM 81528	1975	no*			algal/yeast
Plumigorgia astroplethes	USNM 76298	1976	yes			[e]
Nidalia occidentalis [b]	19-011-01	1977	yes	A/B, 900F/B	A/1200R, 1055F/B	

Species	Specimen #	Date Preserved	Cnidarian Sequences Generated	Initial PCR Amplifications	PCR Reamplifications Required	Contaminant Found
Xenia sp.	USNM 79620	1978	no	A/536R		fungal/plant
Leptogorgia virgulata	USNM 88494	1981	no*			
Nicella guadalupensis	USNM 73722	1981	no	A/B	900F/B	
Telesto fruticulosa	USNM 61122	1981	yes	A/B	A/900R, 900F/B	
Titaniduem frauenfeldii	USNM 88222	1981	no	A/1200R	A/536R	
Carijoa riisei	USNM 86021	1982	no	A/B	900F/B	
Coelogorgia palmosa	USNM 75637	1983	yes	A/705R	A/536R	fungal/bivalve
Nidalia occidentalis	USNM 74730	1983	no[d]			
Plexaurella nutans	USNM 84101	1983	no[d]			
Telesto fruticulosa	USNM 88959	1983	no*			bivalve
Gorgonia ventalina	USNM 88767	1984	yes			symbiont/fungal[e]
Junceella racemosa	USNM 92412	1984	yes	A/B	N/R	
Subergorgia suberosa	USNM 75340	1984	no*			bivalve/fungal/cnidarian
unidentified sp.	unidentified	1984	no*			bivalve
Clavularia modesta	USNM 79765	1985	no	A/705R		
Eunicea laciniata	USNM 73614	1985	yes	A/B	A/1200R, 373F/B	
Isis hippuris	USNM 80861	1985	no	A/536R		
Melitella sp.[a]	N/A	1985	yes	A/705R, 705F/1200R, A/B	705F/1055R, 900F/B	bivalve
Orstomisis crosnieri	USNM 84774	1985	yes	A/B, 373F/B	A/1200R	
Metallogorgia sp.	USNM 89377	1986	no*	A/B		fungal/algal
Heliopora coerulea	USNM 79529	1987	yes	373F/B, A/705R, 900F/B	514F/1055R, A/536R, 1055F/B	fungal/algal
Pennatula grandis	USNM 79776	1987	no[d]			
Solenopodium excavatum	USNM 88852	1987	no*			fungal/bacterial
Nicella obesa	USNM 84332	1988	no	A/536R		
Dendrobrachia paucispina	USNM 97768	1989	yes	A/B	A/1200R, 373F/B	fungal
Junceella gemmacea	USNM 87607	1989	no	A/B	900F/B	
Epiphaxum breve[c]	USNM 91942	1990	yes	A/705R, 900F/B	A/536R, 1055F/B	bacterial/algal
Plumigorgia hydroides[a]	N/A	1992	yes	373F/15560R, 900F/B	514F/1055R, 1055F/B	
Calcigorgia spiculifera	not cataloged	1994	yes	A/B	N/R	

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Table 4   Error rates found in sequences of museum specimens, as seen
            in the pooling of multiple clones from the same PCR reaction,
            and overlapping fragments produced from different PCR
            reactions. (Note: the forward and reverse strands of a single
            clone and a single fragment showed no sequence differences.)
            The species listed here are the only museum specimens for
            which there were overlapping regions or pooled clones.

        a: Error rate within a single PCR reaction as detected from
                pooling multiple clones.
        b: Error rate between PCR reactions as detected in
                fragments shared by overlapping clones.

a)

Specimen	ID Number	Date Preserved	Size of pooled clones (bp)	Number of Transitions	Number of Transversions	Resulting Error (%)
Umbellula sp.	USNM 54656	1971	505, 422	3	2	0.54
Siphonogorgia (Chironephthya) sp	USNM 58584	1973	620, 660	6	2	0.63
Nidalia occidentalis	09-011-01	1977	531, 1430	7	0	0.36
Telesto fruticulosa	USNM 61122	1981	505, 265	1	0	0.13
Junceella racemosa	USNM 92412	1984	505, 545	8	0	0.76
Meltiella sp.	MCZ	1985	694, 628	9	2	0.83
Heliopora coerulea	USNM 79529	1987	603, 533, 758	17	6	1.21
Dendrobrachia paucispina	USNM 97768	1989	865	1	1	0.23
Epiphaxum breve	USNM 91942	1990	530	1	0	0.19
Plumigorgia hydroides	MCZ	1992	710, 525	4	0	0.32
Calcigorgia spiculifera	USNM not cat.	1994	910	0	0	0.00

b)

Specimen	ID Number	Date Preserved	Length of Overlap (bp)	Number of Transitions	Number of Transversions	% Error in Overlap
Siphonogorgia sp.	USNM 55582	1968	459	20	7	5.88
Siphonogorgia (Chironephthya) sp	USNM 58584	1973	450	2	0	0.44
Umbellula sp.	USNM 54597	1974	1800*	0	2	0.11
Nidalia occidentalis	09-011-01	1977	175	0	0	0.00
Junceella racemosa	USNM 92412	1984	507	0	0	0.39
Orstomisis crosnieri	USNM 84774	1985	985	1	2	0.20
Eunicea laciniata	USNM 73614	1985	1015	1	1	0.10
Meltiella sp.	MCZ	1985	445	0	0	0.45
Dendrobrachia paucispina	USNM 97768	1989	1069	0	2	0.01
Protoptilum sp.	USNM	1993	1800*	0	1	0.00
Calcigorgia spiculifera	USNM not cat.	1994	448	2	1	0.67

* Comparing results of replicate extractions of same initial specimen

regions containing these overlaps. The one sequence that showed a high rate of PCR error (5.88% in *Siphonogorgia* sp.) was not used in subsequent phylogenetic analyses.

Several initial attempts at obtaining DNA sequences from museum specimens using universal eukaryotic primers yielded non-cnidarian sequences as indicated through BLAST searches. The contaminant sequences generated were of the algal symbiont *Symbiodinium* sp. and other algal species, various fungi, and occasionally bivalve mollusks and crustaceans. These species were potential symbionts or epibionts of the coral specimens we were analyzing. The use of taxon-specific PCR primers eliminated the amplification of contaminant DNA completely.

Discussion

The protocol outlined here has been successful for generating sequence information from museum specimens preserved up to fifty years. Most genomic DNA extractions from ethanol-preserved specimens were partially degraded, and two rounds of PCR amplifications were required to generate sufficient PCR product for further analyses. The probability of obtaining DNA sequences from contaminant DNA rather than target DNA was significant without the use of taxon-specific primers. The problem of generating non-Cnidarian sequences was eliminated when taxon-specific primers were used in at least one of the two PCR reactions.

A major concern I had with the use of archival specimens was the occasional differences found in overlapping regions of sequence within the same individual. *Taq* DNA polymerase has an inherent rate of error associated with it, which may account for some, if not all, of the replication error observed. Two estimations of the rate of error connected with the use of *Taq* polymerase are 8.0×10^{-6} (errors per base per PCR cycle) (Cline et al. 1996) and 2.1×10^{-4} (Keohavong and Thilly 1989). These error rates applied to the 18S rRNA gene of anthozoans, translate to 0.028%-0.735% error in 35 replication

cycles over the entire gene. For those specimens that were reamplified, the estimated error rate would be 0.056%-1.47% over 70 replication cycles. Only one of the museum specimens exhibited error rates greater than these (5.88% for *Siphonogorgia* sp.). The increased error rate for this specimens may have been due to the presence of damaged DNA. Although the activity of DNA polymerases is slowed by the presence of damaged DNA, particularly at baseless sites, minor lesions such as deaminated bases can produce replication errors without slowing the replication process greatly (Paabo 1989). Therefore, DNA with minor damage will be amplified at the same rate as undamaged DNA. Direct-sequencing of total PCR products will reduce the influence of either type of replication error on the final DNA sequence, since any errors introduced after all but the first rounds of PCR will be evident as ambiguities (Hillis et al. 1996).

PCR amplifications of archival, preserved specimens may not produce sufficient PCR product for direct-sequencing techniques, and cloning of PCR products may be necessary. Since each clone consists of a single PCR product which may contain replication errors, the potential for generating incorrect sequences is heightened (Palumbi, 1996). This is particularly true for these archival specimens since two PCR amplifications were necessary for obtaining DNA sequences from the majority of these samples, thereby increasing the risk of polymerase-introduced errors. This risk makes it particularly important to pool several clones before performing the DNA sequencing reactions; as with determination of sequences directly from PCR products, errors will be evident as ambiguities in the sequence (Medlin et al. 1988). The overall rate of PCR error can then be determined for a given specimen. Depending on the taxonomic scale of phylogenetic analysis being performed, the amount of error found may or may not be significant in the overall analyses. Any amount of error is of concern, however, and one should be aware of the increased chance of such errors when working with preserved specimens. This is

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especially true when analyzing gene flow, as the amount of error may be greater than the genetic signal present.

Protocols for extracting DNA from alcohol-preserved samples are readily available in the literature (Smith et al. 1987; Palumbi et al. 1991), however, very few studies have been published to date using archival ethanol-fixed specimens. The Smith et al. (1987) protocol did not use samples that had been preserved longer than six years. One notable study that used older ethanol-preserved specimens, however, was Persing et al.'s (1990) discovery of the presence of spirochete DNA responsible for Lyme disease in ticks that had been preserved for nearly 50 years. These ticks had been collected 30 years prior to the first documentation of the disease in the United States. Persing et al. (1990) were amplifying very small regions of the mitochondrial genome, however, ranging from 77-200 bp. Fragments this small are sufficient for the detection of the Lyme Disease spirochete genome, but are too small for reliable large-scale phylogenetic studies. The protocol described here allows the generation of larger genomic fragments, which will be useful in studies involving phylogenetics and gene flow, among others.

The phylogenetic analysis of octocoral species is only one of a vast number of studies that can benefit from molecular techniques as applied to archival specimens. I submit here a method that has been successful in generating relatively large PCR fragments of DNA from archival, long-preserved octocoral specimens. There are some general concerns when working with museum specimens, however. My success rate from sample to sample was highly variable, and I did see a small but measurable incidence of PCR-induced sequence error. One is also more likely to encounter the effects of background contamination in the samples when working with older specimens. Despite such difficulties, the use of protocols such as the one outlined above can facilitate the generation of valuable genetic information from preserved museum specimens.

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Chapter 3

Phylogenetic Relationships within the Class Anthozoa (Phylum Cnidaria) Based on Nuclear 18S rDNA Sequence Information

Abstract

Taxonomic relationships within the corals and anemones (Phylum Cnidaria: Class Anthozoa) are based upon few morphological characters: colony morphology and the structure of the tentacles, gastric mesenteries, nematocysts, and skeletal axis. The significance of any given character is debatable, and there is little fossil record available for deriving evolutionary relationships. In this study I use complete sequences of 18S ribosomal DNA to examine subclass-level and ordinal-level organization within the Anthozoa. I investigate whether the traditional two-subclass system (Octocorallia, Hexacorallia) or the current three-subclass system (Octocorallia, Hexacorallia, Ceriantipatharia) is better supported by sequence information. I also examine the phylogenetic affinities of the anemone-like species *Dactylanthus antarcticus* (Order Ptychodactiaria) and the putative antipatharian *Dendrobrachia paucispina*. Thirty-eight species were chosen to maximize the representation of morphological diversity within the Anthozoa. Maximum likelihood techniques were employed in the analyses of these data, using relevant models of evolution for the 18S rRNA gene. I conclude that placing the orders Antipatharia and Ceriantharia into the Subclass Ceriantipatharia does not reflect the evolutionary history of these orders. The Order Antipatharia is closely related to the Order Zoanthidea within the Hexacorallia and the Order Ceriantharia appears to branch early within the Anthozoa, but the affinities of the Ceriantharia cannot be reliably established from these data. My data generally support the two-subclass system, although the Ceriantharia may constitute a third subclass on their own. The Order Corallimorpharia is likely polyphyletic, and its species are closely related to the Order Scleractinia. *Dactylanthus*, also within the Hexacorallia, is allied with the anemones in the Order Actiniaria, and their current ordinal-level designation does not appear to be justified. The genus *Dendrobrachia*, originally classified within the Order Antipatharia, is closer

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phylogenetically to the Subclass Octocorallia. The 18S rRNA gene may be insufficient for establishing concrete phylogenetic hypotheses concerning the specific relationships of the Corallimorpharia and the Ceriantharia, and the branching sequence for the orders within the Hexacorallia. The 18S rRNA gene has sufficient phylogenetic signal, however, to distinguish among the major groupings within the Class Anthozoa, and I can use this information to suggest relationships for several enigmatic taxa.

Introduction

The development of taxonomic systems through traditional, morphological methods can be problematic when the species involved have few distinguishing characters. This is true for species within the Class Anthozoa (Phylum Cnidaria). The Class Anthozoa, containing the stony corals, soft corals, anemones and other anemone-like species, retain their polyp morphology throughout their life history, and lack the medusa stage found commonly in the other classes of the phylum. The primary characters that have been used to derive evolutionary relationships within the Anthozoa include colony morphology and life history, tentacle shape and number, the number and arrangement of divisions within the gastrovascular cavity (termed mesenteries or septa), nematocyst structure, and skeletal structure. The various taxonomic arrangements have arisen from differing interpretations of the significance of these characters (e.g. Wells & Hill 1956a, Hadzi 1963, discussed below). As many Anthozoa lack any type of skeletal structure, there is little fossil record to indicate evolutionary relationships among the major groups of anthozoans.

The validity of the subclass divisions within the Anthozoa has been a subject for debate by taxonomists of both past and present times. The historical subclass divisions within the Class Anthozoa indicate two major groupings, the Subclass Octocorallia and the Subclass Hexacorallia (e.g. Minchin et al. 1900, Pratt 1935, Hyman 1956, Hadzi 1963). The Subclass Octocorallia is composed of the soft corals, gorgonians, blue corals, and sea

pens. Octocorals are distinguished by their possession of eight pinnately branched tentacles and eight complete mesenteries. Their skeletons may contain separate or fused calcium carbonate spicules, and axes of calcium carbonate or chitin or both, and they may be solitary or colonial (Bayer 1956, Wells & Hill 1956a). The Subclass Hexacorallia, in its early definition, contained the remaining anthozoan species: the Actiniaria (anemones), Corallimorpharia, Zoanthidea, Scleractinia (stony corals), Antipatharia (black corals), and Ceriantharia (cerianthid anemones). The subclass was defined by the following characteristics: tentacles simple or divided, but never branched; paired mesenteries, usually in multiples of six; skeleton, if present, without free spicules in the mesoglea. Hexacorals include both solitary or colonial forms.

A third subclass division was proposed as early as 1897, although it wasn't widely accepted until the 1950's or 1960's. The orders Antipatharia and Ceriantharia were removed from the Subclass Hexacorallia and placed in a new subclass, the Ceriantipatharia. The establishment of the Subclass Ceriantipatharia was based primarily on two shared characters between the orders Ceriantharia and Antipatharia: 1) the resemblance of the cerianthid larva to the antipatharian adult polyp, and 2) weak and indefinite musculature associated with the mesenteries (van Beneden 1897). Aside from the above characters, these two orders are considered highly divergent from each other (Wells & Hill 1956b). The Ceriantharia have a unique morphology which distinguishes them from the other Anthozoa. They have two rings of tentacles, and numerous, mostly complete, unpaired mesenteries (Hyman 1956). They possess a unique form of spirocysts (ptychocysts) not present in any other order within the class (Fautin & Mariscal 1991, Rifkin 1991, Goldberg & Taylor 1996). The Ceriantharia have been designated as most primitive within the Hexacorallia, most deeply diverging (Hyman 1940).

The Antipatharia, placed with the Ceriantharia in the Subclass Ceriantipatharia, have been considered to be ancestral with the cerianthids (Wells & Hill 1956a) or highly derived

(recently divergent) hexacorals (Brook 1889, Hickson 1906, Hadzi 1963). Morphological characters suggest affinities among the Antipatharia, Zoanthidea and Actiniaria. All three orders share a type of nematocyst, a microbasic b-mastigophore, which is rare or absent in the other orders of the Anthozoa (Picken & Skaer 1966). Antipatharians, zoanthids, and the Subtribe Endomyaria of the Actiniaria share a common sperm morphology, which is not found in the other anthozoans. The Antipatharia and the Zoanthidea also share similarities in nematocyst structure and skeletal composition (Schmidt 1974), and are thought by some to be highly specialized hexacorals (Hadzi 1963).

Molecular studies using mitochondrial 16S rDNA (France et al. 1996) and 18S rDNA (Song & Won 1997) have shown that the orders Antipatharia and Ceriantharia are genetically divergent from one another, and are not sister orders. The results of these studies disagreed on the positions of the Ceriantharia and Antipatharia relative to the other Anthozoa, however (Fig. 1). A study using 28S rDNA (Chen et al. 1995) and another study combining mt 16S rDNA and 18S rDNA (Bridge et al. 1995), included a single cerianthid as the representative of the Subclass Ceriantipatharia, so would have been unable to detect any potential divergence between the Ceriantharia and the Antipatharia. None of these studies included representatives of the Zoanthidea. Resolution of the phylogenetic affinities and ancestry of the orders Antipatharia and Ceriantharia will further our understanding of the early evolution of the Anthozoa, and may help determine which morphological characters are phylogenetically informative.

The phylogenetic relationships among the orders Corallimorpharia, Scleractinia, and Actiniaria are equivocal based on morphological characters. The Corallimorpharia are morphologically intermediate between the actiniarians and the scleractinians, although their mesentery structure and nematocysts are closer to the scleractinians (Fautin & Lowenstein 1992). At one time, the Corallimorpharia were placed within the same order as scleractinians (Wells & Hill 1956c). In the late 1800's the corallimorpharian species

Fig. 1   Phylogenetic trees from previous molecular studies of the Anthozoa.
A)   From France et al. (1996), based on mitochondrial 16S rDNA
B)   From Song and Won (1997), based on nuclear 18S rDNA
C)   From Chen et al. (1995), based on nuclear 28S rDNA

A

B

C

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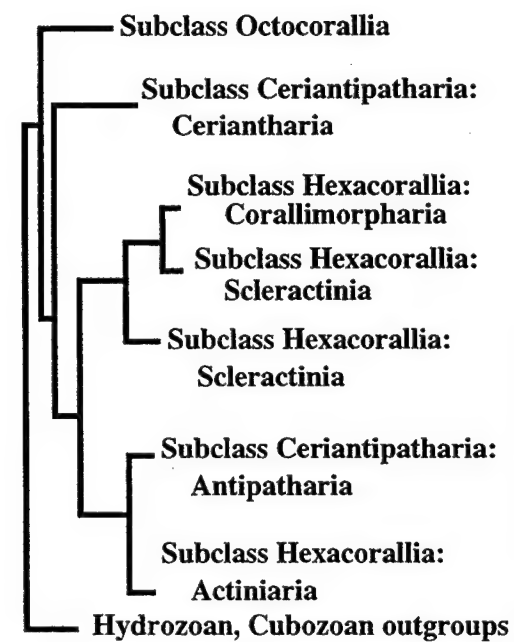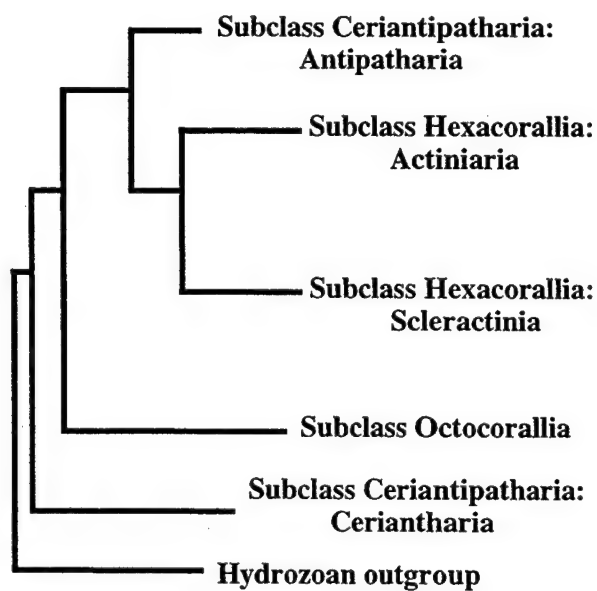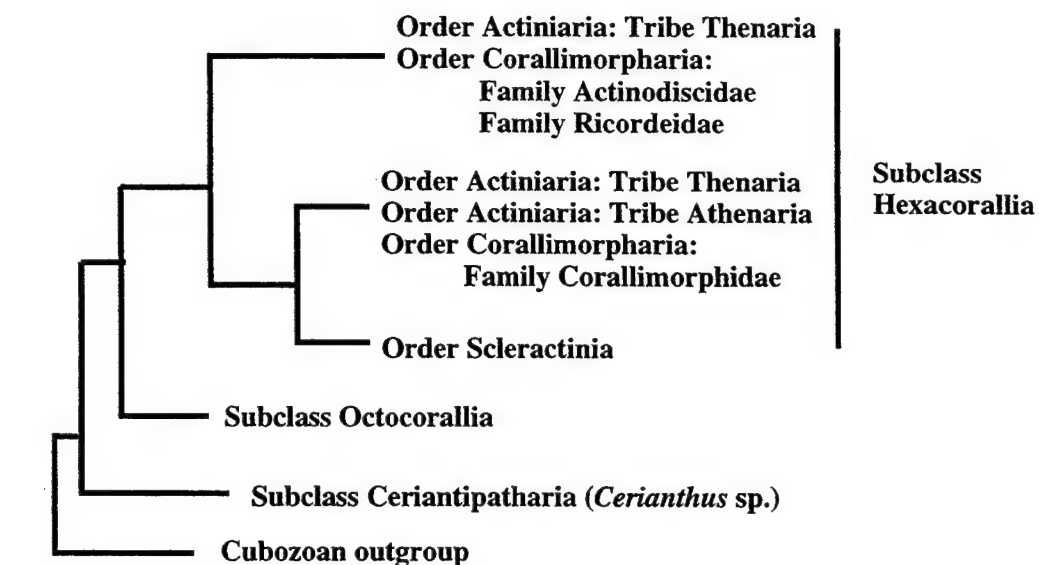
Corynactis was suggested to be an immature scleractinian (Jourdan 1880). The Corallimorpharia have also been considered to be part of the Actiniaria historically (Carlgren 1949). Stephenson (1921) removed the corallimorpharian species from the Actiniaria and designated them as Madreporaria (containing the Corallimorpharia and Scleractinia). Stephenson perceived the Corallimorpharia as Madreporaria that never developed skeletons. Carlgren (1949) established the Corallimorpharia as a separate order. The current scenario gives the three groups equal distinction at the ordinal level within the Subclass Hexacorallia, implying that the presence or absence of a skeleton has greater relevance in identifying phylogenetic affiliations than internal morphology.

Molecular studies have reached different conclusions, however, concerning the relationships among the Actiniaria, Scleractinia, and Corallimorpharia. Partial 28S rDNA sequences (Chen et al. 1995) suggested monophyly of the Scleractinia, and polyphyly of the Corallimorpharia and the Actiniaria (Fig. 1C). Protein radioimmunoassay analyses (Fautin & Lowenstein 1992) indicated that the Corallimorpharia are not distinct from the Scleractinia. Fautin and Lowenstein (1922) hypothesized that the Corallimorpharia may have had multiple origins within the Scleractinia. Mitochondrial 16S rDNA also suggested that the Corallimorpharia branch within the Scleractinia (France et al. 1996).

My study investigated whether the Corallimorpharia were allied with the Scleractinia, the Actiniaria, or neither. The determination of the phylogenetic affinities of the Corallimorpharia should help resolve whether the presence of a skeleton or the internal morphology is more indicative of evolutionary history.

The validity of the current ordinal distinction for the Ptychodactiaria, a group of anemone-like species, is another systematics issue that remains unresolved. The ptychodactiarian species were originally classified as a family within the Actiniaria, included in Protantheae with the Gonactiniidae based on similarities in nematocysts and primitive musculature (Stephenson 1921). The Ptychodactiaria differed from the

Actiniaria, however, in their gonadal arrangement and mesenterial structures (Stephenson 1921, Wells & Hill 1956c). Stephenson (1921, 1922) removed the Ptychodactidae from the Protantheae and created a third tribe, the Ptychodacteae. Carlgren (1949) gave the Ptychodactiaria ordinal ranking, arguing that these characteristics were primitive rather than degenerate. The present work seeks to gain insight not only to the amount of support for their ordinal standing, but also the degree to which these species are ancestral or derived.

The genus *Dendrobrachia* exhibits an interesting combination of morphological characters that resemble both the Antipatharia and the Octocorallia. The *Dendrobrachia* specimen collected in the Challenger Expedition (1872-1876) was in relatively poor condition, but was assigned to the Order Antipatharia based on its chitinous, spiny axis and its lack of sclerites (Brook 1889). *Dendrobrachia* has always been recognized, however, as an 'aberrant' antipatharian (e.g. van Beneden 1897). Additional specimens of *Dendrobrachia* have been shown to possess several characteristically octocorallian features: eight pinnately branched, retractile tentacles, and a solid axial core (Opresko & Bayer 1991). Opresko (1991) suggested that Dendrobrachiidae be established as a family within the Octocorallia, with affinities to the gorgonians. This study will determine whether *Dendrobrachia* is more closely related to the Order Antipatharia (Subclass Ceriantipatharia or Hexacorallia) or the Subclass Octocorallia, and again whether the skeletal morphology is more important evolutionarily than other morphological characters.

For the molecular phylogenetic analyses in the present study I used Maximum Likelihood (ML) techniques, which have only recently become tractable for large data sets (Huelsenbeck & Crandall 1997, Huelsenbeck & Rannala 1997). These methods are appropriate for the analysis of sequence data, as the evolutionary algorithm can be tailored specifically to the gene analyzed (Swofford et al. 1996). As a result, the number of incorrect assumptions about the evolution of the gene can be minimized in the phylogenetic analyses. Without such specific ML methods, the error introduced into phylogenetic

analyses from incorrect assumptions can overwhelm the phylogenetic signal present in the data. This can be a serious problem when working with large numbers of taxa or basepairs (DeSalle et al. 1994, Rzhetsky & Nei 1995). Methods incorporating too many incorrect assumptions will tend to converge on an incorrect tree, given increasing amounts of sequence information (Huelsenbeck & Crandall 1997). For example, using a model employing equal substitution rates within a gene where it is not appropriate can bring the probability of finding the correct tree to zero with sequences greater than 2,000 bp (Sullivan & Swofford 1997). In addition, maximum likelihood analyses produce a statistic (the likelihood score) that can be useful for comparing specific evolutionary hypotheses (i.e. phylogenetic trees). This statistic will indicate if a given hypothesis is significantly better or worse than an alternative (Hillis 1995, Huelsenbeck & Rannala 1997).

The previous phylogenetic studies of the Anthozoa had limitations for addressing the scope of questions I ask here. All of the studies had limited taxon sampling within the Hexacorallia (Bridge et al. 1995, Chen et al. 1995, France et al. 1996, Song & Won 1997) or Ceriantipatharia (Bridge et al. 1995, Chen et al. 1995), and included only partial gene sequences. These studies used relatively basic phylogenetic analyses (parsimony and distance) employing evolutionary models that are not highly accurate with respect to the data set. The goal of my study was to build a more complete phylogeny of the Class Anthozoa than currently exists, containing representatives from across the morphological breadth present within the class, using complete 18S rDNA sequences. This study addresses a number of questions regarding anthozoan phylogeny: 1) are the Ceriantharia and the Antipatharia phylogenetically allied within the Subclass Ceriantipatharia, separate from the Subclass Hexacorallia, 2) are the Corallimorpharia affiliated with the Actiniaria, the Scleractinia, or other members of the Hexacorallia, 3) are the Ptychodactiaria phylogenetically distinct from the Actiniaria, 4) is *Dendrobrachia* affiliated with the Antipatharia (Subclass Hexacorallia) or the Subclass Octocorallia, and 5) which

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morphological characters are correlated most closely with phylogenetic divisions within the Anthozoa?

I chose the nuclear 18S rRNA gene for this study because it has been shown repeatedly to be useful in addressing questions on a variety of evolutionary scales, ranging from differentiation of kingdoms (e.g. Wainright et al. 1993) to elucidation of relationships within a given order (e.g. Kelly-Borges et al. 1991, Hay et al. 1995) or even within a single family (e.g. Kuznedelov & Timoshkin 1993, Fitch et al. 1995). I address some of the conflicting results from previous molecular studies using maximum likelihood analyses, which can incorporate relevant evolutionary assumptions for the 18S rRNA gene in anthozoans, and suggest hypotheses for issues where no molecular information has previously existed.

Methods

Specimens

This study included over 1600 basepairs (bp) of sequence information from the nuclear 18S rRNA gene of 40 anthozoan species plus 7 outgroup species, representing all of the extant orders of the Anthozoa. Fifteen of the sequences used were taken from Genbank, and the remaining 32 were determined for this study. The species came from a variety of sources (Table 1). Several octocoral specimens and the specimen of *Dendrobrachia paucispina* were acquired from Dr. Frederick Bayer of the National Museum of Natural History and Ardis Johnston of the Harvard Museum for Comparative Zoology. These specimens had been stored in ethanol for periods ranging from two to 50 years. No information was available as to whether the samples were fixed originally in ethanol or in formalin. Fresh specimens of octocorals, zoanthids, antipatharians, and actiniarians were collected by submersible from Hawaiian seamounts (using the Pisces V submersible, operated by the Hawaiian Undersea Research Laboratory at the University of Hawaii) and

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Table 1   Specimens used in phylogenetic analyses. Species of
           Placozoa, Porifera, Ctenophora, Hydrozoa and Cubozoa were
           used as outgroups. Specimen sources are as follows: Bishop
           Seamount, 18.8°N 159.1°W; CG, courtesy of Constance
           Gramlich, UCSD; EG, courtesy of Erica Goldman, University
           of Washington; Fieberling Guyot, 32.1°N 127.8°W; LP,
           courtesy of Dr. Lloyd Peck of the British Antarctic Program
           and Dr. Daphne Fautin of the Division of Invertebrate Zoology
           at Kansas University Natural History Museum; NMNH,
           provided by Dr. Frederick Bayer, National Museum of Natural
           History, Smithsonian; Pensacola Seamount, 18.3°N 157.3°W;
           SR, courtesy of Dr. Sandra Romano, University of Guam;
           WG, courtesy of Dr. Walter Goldberg, Florida International
           University.

Species	Source	ID #	Genbank Accession #
Phylum Porifera			
Class Calcarea			
Scypha ciliata	Genbank		D15066
Class Demospongiae			
Tetilla japonica	Genbank		D15067
Phylum Ctenophora			
Mnemiopsis leidyi	Genbank		L10826
Beroe cucumis	Genbank		D15068
Phylum Placozoa			
Trichoplax sp.	Genbank		Z22783
Phylum Cnidaria			
Class Hydrozoa			
Selaginopsis cornigera	Genbank		Z92899
Class Cubozoa			
Tripedalia cystophora	Genbank		L10829
Class Anthozoa			
Subclass Octocorallia			
Order Pennatulacea			
Suborder Sessiliflorae			
Fam. Protoptilidae			
Protoptilum sp.	Bishop Seamount, HI, 1440 m	BI101-3	AF052911
Fam. Renillidae			
Renilla reniformis	Mission Bay, CA, 8 mCG		AF052581
Fam. Umbellulidae			
Umbellula sp.	Bahamas, 1447 mNMNH	54597	AF052904
Suborder Subselliflorae			
Fam. Virgulariidae			
Acanthoptilum sp.	Mission Bay, CA, 8 mCG		AF052910

Taxonomy	Locality	ID	Accession
Order Alcyonacea			
Suborder Protoalcyonaria			
Fam. Taiaroidae			
Taiaroa tauhou	Otago Penninsula, NZ, 420-320 m[NMNH]	54271	AF052908
Suborder Stolonifera			
Fam. Tubiporidae			
Tubipora musica	Bikini Atoll, Marshall Islands[NMNH]	79459	AF052909
Suborder Alcyoniina			
Fam. Alcyoniidae			
Bellonella rigida	Genbank		Z49195
Suborder Scleraxonia			
Fam. Briareidae			
Briareum asbestinum	San Blas Islands, Panama[TG]		AF052912
Suborder Holaxonia			
Fam. Acanthogorgiidae			
Acanthogorgia sp.	Bishop Seamount, HI, 1285 m	BII04-3	AF052907
Fam. Dendrobrachiidae			
Dendrobrachia paucispina	Great Australian Bight, 884-859 m[NMNH]	87768	AF052903
Fam. Isididae			
Lepidisis sp.	Pensacola Seamount, HI, 1425 m	PN104-1	AF052906
Fam. Primnoidae			
Narella bowersi	Pensacola Seamount, HI, 1350 m	PN105-3	AF052905
Subclass Hexacorallia			
Order Actiniaria			
Suborder Nynantheae			
Tribe Thenaria			
Subtribe Endomyaria			
Fam. Actiniidae			
Anemonia sulcata	Genbank		X53498
Anthopleura kurogane	Genbank		Z21671
Subtribe Mesomyaria			
Fam. Actinostolidae			
Stomphia sp.	Friday Harbor, WA, subtidal[EG]		AF052888

Taxon	Location	Code	Accession
Subtribe Acontiaria			
Fam. Metrididae			
Metridium sp.	Woods Hole, MA, subtidal		AF052889
Fam. Hormathiidae			
Hormathiid anemone	Fieberling Guyot, 640 m	AD2294-2	AF052890
?Actiniaria sp.	Fieberling Guyot, 490 m	AD2301-1	AF052880
Fam. Isophelliidae			
Flosmaris mutsuensis	Genbank		Z92905
Tribe Athenaria			
Fam. Haloclavidae			
Haloclava sp.	Woods Hole, MA, subtidal		AF052891
Order Scleractinia			
Suborder Fungiina			
Fam. Agariciidae			
Pavona varians	Hawaii[SR]		AF052883
Fam. Fungiidae			
Fungia scutaria	Hawaii[SR]		AF052884
Suborder Dendrophylliina			
Fam. Dendrophylliidae			
Enallopsammia rostrata	Bishop Seamount, HI, 1200 m	BI106-2	AF052885
Rhizopsammia minuta	Genbank		Z92907
Tubastraea aurea	Genbank		Z92906
Suborder Caryophylliina			
Fam. Caryophylliidae			
Ceratotrochus magnaghii	Mediterranean[SR]		AF052886
Phyllangia mouchezii	Mediterranean[SR]		AF052887
Order Ptychodactiaria			
Fam. Ptychodactiidae			
Dactylanthus antarcticus	Signy Island, Antarctica[LP]		AF052896
Order Zoanthidea			
Suborder Macrocnemina			
Fam. Parazoanthidae			
Parazoanthus axinellae	Genbank		U42453
Parazoanthus sp.	Fieberling Guyot, 490 m	AD2296-1	AF052893
Suborder Brachycnemina			
Fam. Zoanthidae			
Palythoa variabilis	Bermuda, subtidal		AF052892

Order Corallimorpharia
   Fam. Discosomatidae
      Discosoma sp.   Bermuda, subtidal   AF052894
   Fam. Corallimorphidae
      Corynactis californica   aquarium specimen, University of New Hampshire   AF052895

Subclass Ceriantipatharia
   Order Ceriantharia
   Order Ceriantharia
      Fam. Cerianthidae
         Cerianthus borealis   Nubble Lighthouse, ME, subtidal   AF052897
         Ceriantheopsis americanus   Fort Pierce Inlet, FL, 0.5 m   AF052898
   Order Antipatharia
      Fam. Antipathidae
         Stichopathes spiessi   Fieberling Guyot, 490 m   AD2296-14   AF052899
         Antipathes fjordensis   Bradshaw Sound, Fiordland NZ   WG   AF052900
         Antipathes lata   Genbank   Z92908
         Bathypathes sp.   Penguin Bank, HI, 418 m   PBS-5a   AF052901
         Cirripathes lutkeni   Hollywood, FL, 25 m   WG   AF052902

Fieberling Guyot (using the Alvin submersible, operated by the Woods Hole Oceanographic Institution). The specimens collected from these dives were either frozen in liquid nitrogen or in a -20°C freezer. Other actiniarian and corallimorpharian specimens were collected in U.S. and Bermuda by snorkeling or SCUBA. Two antipatharian specimens were donated by Dr. Walter Goldberg of the Florida International University. The ptychodactiarian specimen was donated by Dr. Lloyd Peck of the British Antarctic Program and Dr. Daphne Fautin of the Division of Invertebrate Zoology at Kansas University Natural History Museum. DNA extractions of scleractinians and several octocorals were donated by Dr. Sandra Romano of the University of Guam Marine Station and Dr. Tamar Goulet of the State University of New York, Buffalo, respectively.

DNA Extraction Protocol

The DNA extraction protocols I used was similar to those described by Coffroth et al. (1992) and Winnepenninckx et al. (1993). Five to ten polyps of fresh or frozen tissues were minced with a razor blade and placed in a 1.5-ml eppendorf tube with 600 µl of 2X cetyltrimethylammonium bromide (CTAB) buffer (1.4M NaCl, 0.02M EDTA, 0.1M Tris-HCl (pH 8.0), 2% CTAB (Sigma Chemical Co.), and 0.2% beta-mercaptoethanol). This buffer is particularly effective at removing polysaccharides that are abundant in coral tissues, and which can interfere with DNA extraction. A plastic dounce was employed to shear the tissue further, and an additional 300 µl of 2X CTAB was added. The samples were placed at 55°C and digested with 5 µl of proteinase K (20 mg/ml) for approximately two hours. The tissues were extracted once with an equal volume of 24:1 chloroform:isoamyl alcohol, and precipitated in two volumes of cold 95% ethanol at -20°C overnight. The tubes were centrifuged at 10,000xg for 30 minutes, and the ethanol was removed. The pellets were washed with 500 µl cold 70% ethanol, and the tubes were centrifuged at 7,000xg for 15 minutes. The ethanol was removed, and the pellets dried at

room temperature. The pellets were resuspended in 50 µl of TE buffer (10 mM Tris-HCl--

pH 8.0, 1 mM EDTA--pH 8.0) and placed at 4°C for three to four hours before

visualization on an agarose gel.

The ethanol-preserved specimens were extracted with a slightly different protocol.

Five to ten polyps of the archival specimens were placed on ice in two to ten ml 2X CTAB

buffer for two to 24 hours, with the buffer replaced several times during this period. The

buffer was removed, and the tissue minced finely with a razor blade as above. The tissues

were incubated with proteinase K at 55°C for 24 hours, with periodic agitation. Another 5

µl of proteinase K was added, and the tissues continued to digest for an additional eight to

twelve hours. The remaining extraction procedure followed as above.

DNA Amplification Protocols

Pipet tips with a filter barrier were used throughout this process to guard against

contamination of the reactions. Negative controls were included during the DNA

extractions and PCR reactions to detect contamination if it did occur. Each extracted DNA

sample was diluted 1:10 in TE buffer, and 2 µl of that dilution was used in a 50 µl PCR

reaction. Modified versions of the universal eukaryotic primers A and B (with the

polylinkers removed) from Medlin et al. (1988) were used in the initial DNA amplifications

of the 18S rRNA gene. Primer sequences are as follows: A (forward) 5'-

AACCTGGTTGATCCTGCCAGT-3', B (reverse)-- 5'-

TGATCCTTCTGCAGGTTCACCTAC-3'. We found the 18S rRNA gene to be roughly

1800 bp in length in anthozoans. Thirty-five cycles of PCR were carried out using a

Perkin Elmer Thermal Cycler 480. The DNA was denatured at 94°C for 45 seconds, the

primers and template were annealed at 55°C for one minute, and the original DNA strand

was extended at 72°C for 90 seconds. These 35 cycles were followed by a five minute

extension at 72°C. The product was visualized on a 1% agarose gel. There was always a visible product from the fresh or frozen tissues, and that product was prepared for cloning.

For those museum specimens that yielded no visible PCR product, a second PCR reaction was conducted using 1 µl of product from the initial PCR reaction as the template. The amplified negative control (no DNA was added to the tube) from the initial PCR reaction was included in the second reaction, using 1 µl of the original negative control as template. The primers used for the second PCR reaction were chosen to ensure that at least one primer annealed internally to the initial A and B primers. The internal primers were selected from a combination of universal eukaryotic primers and a set of octocoral-specific primers that were designed by me. The universal primers were the following: 373 (forward) 5-'GATTCCGGAGAGGGAGCCT-3' and 1200 (reverse) 5'-GGGCATCACAGACCTG-3' (Weekers et al. 1994), 514 (forward) 5'-GTGCCAGCMGCCGCGG-3', 1055 (forward) 5'-GGTGGTGCATGGCCG-3', and 1055 (reverse) 5'-CGGCCATGCACCACC-3' (Elwood et al. 1985), and 536 (reverse) 5'-WATTACCGCGGCKGCTG-3' (Lane et al. 1985). The octocoral-specific primers were designed to amplify anthozoan DNA, but not DNA from the potential contaminants. The octocoral-specific primers were designed from alignments of GenBank sequences of actiniarians (found in Table 1), two fungi (*Cryptococcus neoformans*, Genbank accession #L05428, and *Bullera unica*, accession #D78330), potential epibionts from Mollusca and Crustacea (*Mytilus galloprovincialis*, accession #L33451, and *Stenocypris major*, accession #Z22850), and a zooxanthella symbiont (*Symbiodinium* sp., accession #M88509). Octocoral sequences derived from frozen tissue in this laboratory (Table 1) were verified as cnidarian through a BLAST search of GenBank and were also used in the primer design. Octocoral-specific primers were the following: 705 (forward) 5'-GGTCAGCCGTAAGGTTT-3', 705 (reverse) 5'-CATACCTTTCGGCTGACC-3', 900 (forward) 5'-GTTGGTTTTTTGAACCGAAG-3', 900 (reverse) 5'-

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CTTCGGTTCTAGAAACCAAC-3', 1560 (reverse) 5'-GGTGAAGGAGTTACTCGATG-3'. PCR primer pairs were chosen to include at least one octocoral-specific primer, and to amplify the largest fragment possible from the archival specimens. Further details and the rationale behind this technique can be found in Chapter 2.

Determination of DNA Sequences

The final PCR product was cloned using the Original TA Cloning Kit (Invitrogen Corporation). The PCR product was ligated into the pCR 2.1 cloning vector, then transformed into a strain of INVαF' cells. The plasmid was isolated using the Wizard Miniprep DNA Purification Kit (Promega Corporation) and subsequently used as a template for cycle sequencing reactions, using the SequiTherm EXCEL Long-Read DNA Sequencing Kit-LC (Epicentre Technologies). DNA sequences were determined for both the forward and reverse strands of the gene. The reactions were run on a LI-COR 4000 DNA Sequencer, using infrared-labeled primers: M13 (forward) 5'-CACGACGTTGTAAAACGAC-3', M13 (reverse) 5'-GAATAACAATTTCACACAGG-3', 514 (forward) 5'-TCTGGTGCCAGCASCCGCGG-3', 536 (reverse) 5'-TGGWATTACCGCGGSTGCTG-3', 1055 (forward) 5'-GTGGTGGTGCATGGCCG-3', 1055 (reverse) 5'-AAGAACGGCCATGCACCAC-3'. The resulting images were interpreted using the BioImage gel reader program.

Sequence Analysis

DNA sequences were aligned first by eye, with consideration of secondary structure models, and with the alignment program Clustal W 1.6 (Thompson et al. 1994). Regions of uncertain alignment were eliminated from the final analyses (the nexus file is available upon request). In total, 1609 basepairs were used in the analyses, of which 247

out of 541 variable sites were parsimony-informative, and 294 were parsimony-uninformative.

All analyses were performed using test versions of PAUP* (ver. 4d61, 4d63) (Swofford 1996, betatest version). An initial distance analysis of the entire dataset was performed using a Kimura 2-parameter model. The likelihood scores were calculated for that tree using a variety of ML models, incorporating combinations of base-dependent rates of change with unequal base frequencies, a proportion of invariant sites, and substitutional rate heterogeneity. The purpose of this procedure was to identify the simplest model of evolution that was still accurate for this data set; the simpler model has a lower variance (Rzhetsky & Nei 1995) and is less computationally intensive. Using a Likelihood Ratio Test (LRT) similar to the one described by Huelsenbeck and Rannala (1997), the likelihood scores (L) of simpler models were compared to that of the most complex reference model (a general time-reversible model with among-site substitution heterogeneity): LRT=2([-lnL*reference*] - [-lnL*alternative*]). The values of the LRT are approximately Chi-square distributed, with the degrees of freedom equal to the difference in free parameters between the models being tested. Models for which the LRT score was greater than the Chi-squared critical value were rejected as not being sufficiently accurate.

Likelihood scores were also used to test specific phylogenetic hypotheses addressed by this study. Alternative evolutionary hypotheses were formed by manipulating tree topologies using the computer program MacClade (Maddison & Maddison 1992). The Kishino-Hasegawa (KH) Test (Kishino & Hasegawa 1989) within the PAUP* program was used to compare the likelihood scores of different topologies (i.e. evolutionary hypotheses). Trees were viewed using PAUP* and the free-ware program TreeView (Page 1996).

Results

The large number of taxa and lengths of each sequence included in these analyses made it unlikely that simple parsimony or distance methods would be sufficient for detecting the phylogenetic signal within this data set. When using subsets of the data, e.g. 23 out of the 47 taxa, bootstrap analyses of both parsimony and Kimura two-parameter distance methods gave trees with well-supported topology as defined by high bootstrap values. When the full data set was used, however, the placement of the Order Ceriantharia changed substantially, and the bootstrap values of the basal nodes dropped from 80-100% in the subset analysis to 50-60% and below with the full data set. The results from the LRT using the original Kimura 2-parameter tree showed that simple parsimony and distance models were insufficient to model the evolution of this gene, and that the appropriate model for the analysis of this data set was a general time-reversible model (GTR) with among-site heterogeneity. All simpler models were statistically inferior to the full GTR model for explaining this neighbor-joining tree given these data. The parameters estimated from the Kimura 2-parameter tree (Table 2) were used in a heuristic ML search consisting of five replicates, with random addition of sequences. The parameters were re-estimated using the most likely tree that was produced from that ML analysis, to insure there were no substantial changes. The most likely trees were found within the first replicate in all analyses conducted.

Seven species were tested as potential outgroups for these analyses: two species from Phylum Porifera, two species from Phylum Ctenophora, one species from Phylum Placozoa, and two other species from the Phylum Cnidaria, representing classes Hydrozoa and Cubozoa (Table 1). Species were tested individually and as a group to determine their effect on the overall tree topology. The major clades were present regardless of the taxa chosen for the outgroup, with the exception of *Trichoplax*. When *Trichoplax* was used as

Sequence Parameter	Value
Base frequencies	
A	0.257
C	0.206
G	0.275
T	0.262
Substitution R matrix	
A/C	0.9458
A/G	2.6447
A/T	0.7776
C/G	1.6166
C/T	4.9021
Proportion of invariant sites	0.3807
Gamma distribution	
α	0.5889

Table 2 **Sequence parameter values calculated from the 18S rDNA used in the present study. Values used as input for maximum likelihood analyses. The R matrix contains base-specific substitution rates. The gamma distribution parameter α is the inverse of the coefficient of variation of the substitution rate.**

the sole outgroup, the major clades which had been well-supported were broken up and the hexacorals were no longer monophyletic. Polyphyly of the Hexacorallia is inconsistent with traditional morphological taxonomy, and has not been shown by previous molecular phylogenies, and it is therefore likely that *Trichoplax* by itself is an inappropriate outgroup for these analyses. When all outgroups were used together, the general tree topology was once again as seen in the majority of the outgroup trials.

The positional stability of the outgroups was examined in addition to their overall effect on tree topology. Although the combined use of *Mnemiopsis leidyi* (ctenophore) and *Selaginopsis cornigera* (hydroid) as the only outgroups produced the expected tree topology, M. leidyi could then be moved to multiple positions on the topology, including to the ingroup, without reducing the likelihood score significantly (KH Test, P<0.05). *Mnemiopsis leidyi* with *S. cornigeras* alone may be an inappropriate outgroup, since *M. leidyi* doesn't branch reliably at the root of the tree. When all outgroup species were used, the root became stable; the outgroup species could only be placed at the root or the adjoining basal node without reducing the likelihood score significantly. Monophyly of the ingroup could not be rejected. The final analyses for this data set were performed using all seven taxa as outgroups.

Parsimony and distance methods showed that the orders Actiniaria, Zoanthidea, Scleractinia, Antipatharia, and Ceriantharia, as well as the Subclass Octocorallia, constitute monophyletic groupings (data not shown). The Corallimorpharia do not appear to be monophyletic. Since the primary issues to be addressed here were the ordinal-level relationships within the Anthozoa, the topology and monophyly of the Scleractinia and the Octocorallia were fixed for the ML analyses to decrease computational complexity (i.e. effectively reducing the number of taxa from 41 to 25) and to concentrate the analytical efforts on the above issues. One most likely tree was produced from a ML analysis (Fig.

2). The orders that were not fixed retained the monophyly found in distance and parsimony analyses.

The most likely tree (Fig. 2) indicated that the Subclass Ceriantipatharia is not a monophyletic grouping. The Order Ceriantharia was basal to the Hexacorallia, and the Order Antipatharia fell within the Subclass Hexacorallia, as a sister group to the Order Zoanthidea. The two species of the Ceriantharia clustered consistently with each other, but the placement of the Ceriantharia branch was not stable. Although the most likely tree placed the Ceriantharia in an ancestral position relative to the Hexacorallia, the cerianthids could then be placed in numerous positions throughout the Actiniaria, Antipatharia, within the Octocorallia, and at the base of most subclades without reducing the likelihood of the tree significantly (KH Test, $P>0.05$) (Fig. 3). The cerianthids appear to be highly divergent from the other Anthozoa, but they have evolved in such a way that the phylogenetic signal from their sequences could not indicate their specific phylogenetic affinities within the Anthozoa. Their position could not be placed reliably using nuclear 18S rRNA data. The two cerianthid species were eliminated from further analyses in order to reduce the computational noise resulting from their sequences.

The computational complexity of the analyses was reduced further by fixing the relationships within the Actiniaria, the Antipatharia, the Zoanthidea, the Scleractinia, and the Octocorallia, as they were found in parsimony analyses. This effectively reduced the number of taxa in the analysis from 45 to 14. This approach was justified based on the solid bootstrap support for monophyly, as seen in a ML-calculated distance analysis (Fig. 4), as well as results from parsimony and ML analyses (data not shown). The fixation of these nodes allowed the ML algorithm to concentrate on the relationship of the basal nodes, which represent the relationships among the primary clades.

A single most likely tree was found from the subsequent ML analysis (Fig. 5). The Subclass Octocorallia formed a sister clade to the Hexacorallia. Within the hexacoral clade,

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Fig. 2   The most likely tree produced from maximum likelihood
analyses of the Anthozoa, with topologies of the octocoral
clade and scleractinian clade fixed (circled) (-LN likelihood =
11919.609).   The relative positions of the orders within the
Hexacorallia and Ceriantipatharia (Scleractinia,
Corallimorpharia, Antipatharia, Zoanthidea, Actiniaria, and
Ceriantharia) are interchangeable without reducing the likelihood
of the tree significantly (KH Test, P<0.05).   Horizontal branch
length reflects genetic distance among taxa.   Outgroup genera
are *Tetilla, Scypha, Beroe, Mnemiopsis, Trichoplax, Tripedalia*
and *Selaginopsis*.
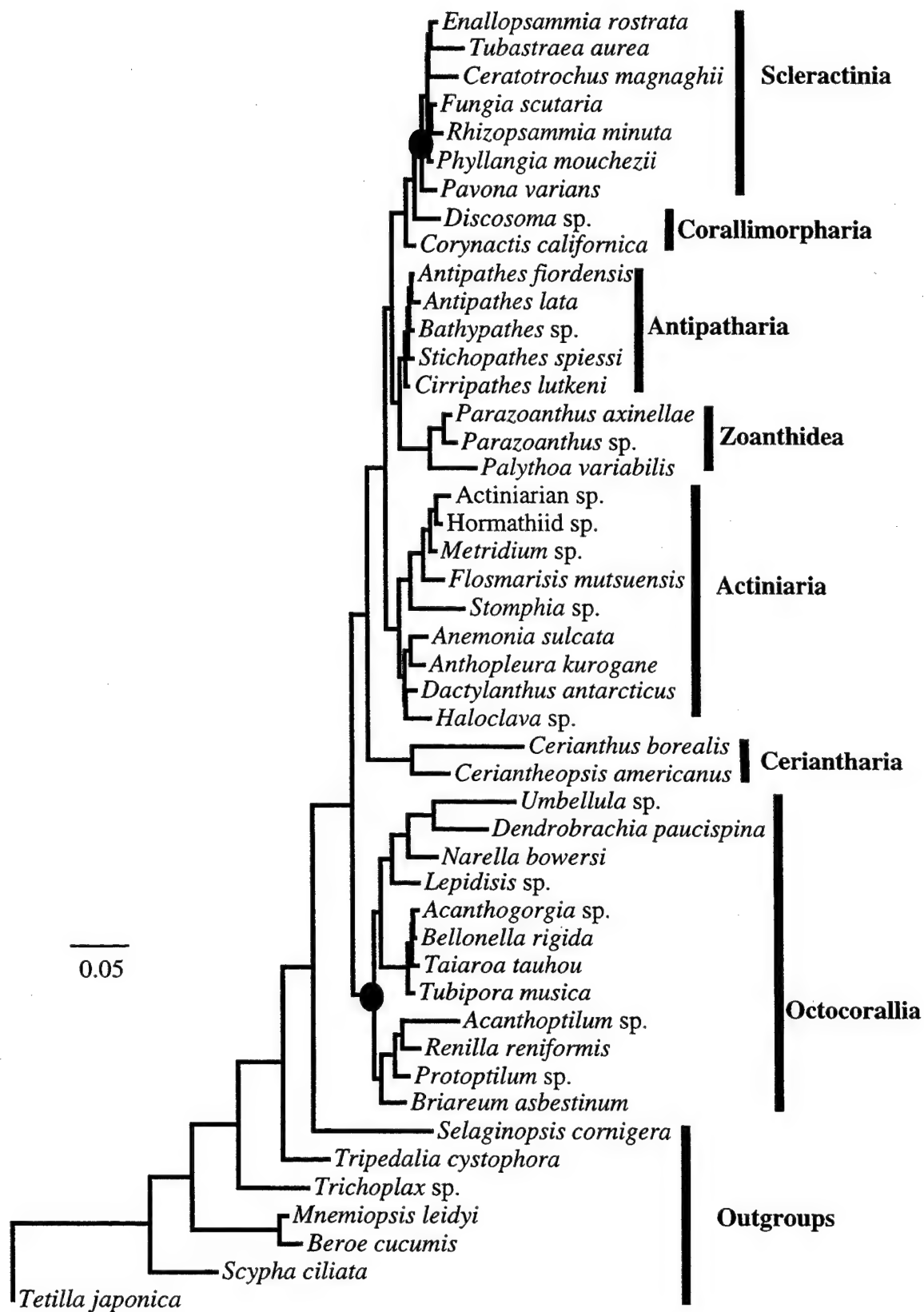
Fig. 3   Possible placements of the Ceriantharia that do not reduce the
         likelihood of the tree. The X's mark the positions where one or
         both species of the Order Ceriantharia can be placed without a
         significant reduction of the likelihood score of the tree (KH
         Test, P<0.05).   Horizontal branch length does not reflect
         genetic distance. Outgroup genera are *Tetilla*, *Scypha*, *Beroe*,
         Mnemiopsis, *Trichoplax*, *Tripedalia* and *Selaginopsis*.

Tetilla japonica
Scypha ciliata **Outgroups**
Trichoplax sp.

X *Stomphia* sp.
X *Anemonia sulcata*
X *Anthopleura kurogane*
X *Dactylanthus antarcticus* **Actiniaria**
X *Haloclava* sp.
X *Flosmaris mutsuensis*
X *Metridium* sp.
X Actiniarian sp.
X Hormathiid sp.

Corynactis californica
Ceratotrochus magnaghii
Discosoma sp.
Pavona varians
Enallopsammia rostrata **Scleractinia/**
Phyllangia mouchezii **Corallimorpharia**
Fungia scutaria
Rhizopsammia minuta
Tubastraea aurea

X *Cirripathes lutkeni*
X *Stichopathes spiessi*
X *Bathypathes* sp. **Antipatharia**
X *Antipathes fiordensis*
X *Antipathes lata*

Palythoa variabilis
X *Parazoanthus axinellae* **Zoanthidea**
Parazoanthus sp.

X *Briareum asbestinum*
Lepidisis sp.
Narella bowersi
Umbellula sp.
Dendrobrachia paucispina
Protoptilum sp.
X *Acanthoptilum* sp. **Octocorallia**
Renilla reniformis
Tubipora musica
Taiaroa tauhou
Acanthogorgia sp.
Bellonella rigida

X *Selaginopsis cornigera*
Tripedalia cystophora **Outgroups**
Mnemiopsis leidyi
Beroe cucumis

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Fig. 4   **Bootstrap analysis using distances calculated from maximum likelihood parameters, showing support for monophyly of the ordinal nodes. No taxa were fixed for this computation. Horizontal branch length reflects genetic distance among taxa.**

Scypha ciliata

Tetilla japonica **Outgroups**

Trichoplax sp.

Stomphia sp.

Anemonia sulcata

Anthopleura kurogane

100 *Dactylanthus antarcticus* **Actiniaria**

Haloclava sp.

Metridium sp.

Flosmaris mutsuensis

Actiniarian sp.

81 Hormathiid sp.

Cirripathes lutkeni

100 *Stichopathes spiessi*

Bathypathes sp. **Antipatharia**

Antipathes fiordensis

63 *Antipathes lata*

Ceratotrochus magnaghii

Corynactis californica

90 *Pavona varians*

100 *Discosoma* sp. **Scleractinia/**

Phyllangia mouchezii **Corallimorpharia**

Enallopsammia rostrata

Fungia scutaria

Rhizopsammia minuta

Tubastraea aurea

100 100 *Palythoa variabilis* **Zoanthidea**

Parazoanthus axinellae

Parazoanthus sp.

Briareum asbestinum

Lepidisis sp.

Narella bowersi

Umbellula sp.

Dendrobrachia paucispina

100 *Tubipora musica*

Acanthogorgia sp. **Octocorallia**

Bellonella rigida

Taiaroa tauhou

87 *Protoptilum* sp.

Acanthoptilum sp.

Renilla reniformis

83 *Selaginopsis*

Tripedalia cystophora **Outgroups**

100 *Mnemiopsis leidyi*

Beroe cucumis

0.01

71

81

100

91

107

Fig. 5   Most likely tree produced from maximum likelihood
           analyses, showing the most basal relationships present
           among the Hexacorallia (-Ln likelihood = 11072.545).   The
           topologies of the Actiniaria, Antipatharia, Scleractinia,
           Zoanthidea, and Octocorallia were fixed to simplify
           computational complexity (circled).   Horizontal branch length
           reflects genetic distance among taxa.

Scleractinia

- *Enallopsammia rostrata*
- *Tubastraea aurea*
- *Ceratotrochus magnaghii*
- *Fungia scutaria*
- *Rhizopsammia minuta*
- *Phyllangia mouchezii*
- *Pavona varians*
- *Discosoma* sp.
- *Corynactis californica*

Corallimorpharia

- *Stichopathes spiessi*
- *Bathypathes* sp.
- *Cirripathes lutkeni*
- *Antipathes fiordensis*
- *Antipathes lata*

Antipatharia

- *Parazoanthus axinellae*
- *Parazoanthus* sp.
- *Palythoa variabilis*

Zoanthidea

- Actiniarian sp.
- *Flosmaris mutsuensis*
- *Hormathiid* sp.
- *Metridium* sp.
- *Stomphia* sp.
- *Anemonia sulcata*
- *Anthopleura kurogane*
- *Dactylanthus antarcticus*
- *Haloclava* sp.

Actiniaria

- *Umbellula* sp.
- *Dendrobrachia paucispina*
- *Narella bowersi*
- *Lepidisis* sp.
- *Acanthogorgia* sp.
- *Bellonella rigida*
- *Taiaroa tauhou*
- *Tubipora musica*
- *Acanthoptilum* sp.
- *Renilla reniformis*
- *Protoptilum* sp.
- *Briareum asbestinum*

Octocorallia

- *Selaginopsis cornigera*
- *Tripedalia cystophora*
- *Trichoplax* sp.
- *Mnemiopsis leidyi*
- *Beroe cucumis*
- *Scypha ciliata*
- *Tetilla japonica*

Outgroups

0.04

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the Actiniaria were most basal. The Antipatharia formed a sister clade to the Zoanthidea. The Corallimorpharia were polyphyletic, and basal to the Scleractinia. The topology of ordinal clades within the Hexacorallia can be varied without reducing the likelihood of the tree significantly (KH Test, P<0.05).

The 18S rRNA gene contained sufficient phylogenetic signal to suggest relationships for both the ptychodactiarian species *Dactylanthus antarcticus* and the putative antipatharian *Dendrobrachia paucispina*. Neither of these species was constrained for the initial analyses, as I wanted to determine their position relative to the other Anthozoa. The ptychodactiarian *Dactylanthus* was firmly allied with the Order Actiniaria. A separate ML analysis was conducted including only *Dactylanthus*, the Actiniaria, and a subset of the outgroup species. New ML parameters were calculated to reflect the change in taxonomic sampling. The most likely tree (Fig. 6) placed *Dactylanthus* with the species *Haloclava* sp..

Dendrobrachia paucispina was placed clearly within the octocoral clade, and branched with the species *Umbellula* sp. and *Narella bowersi*. All other positions for *Dendrobrachia* on this tree reduced the likelihood significantly (KH Test, P<0.05).

Discussion

These molecular analyses support the morphological division between the Subclass Octocorallia and the other Anthozoa, which was based primarily on mesentery and tentacle structure. The octocorals' octamerous mesenteries and pinnately-branched tentacles are unique to the Anthozoa, as are their mesenchymal skeletal spicules. The octocorals also share a single type of nematocyst (basitrichs) which are rare or absent in the Actiniaria (Picken & Skaer 1966, Schmidt 1974). The remaining species within the Anthozoa, which comprise the early Subclass Hexacorallia, are more diverse in their morphology. They are characterized by simple, unbranched tentacles, and generally by six or more pairs of
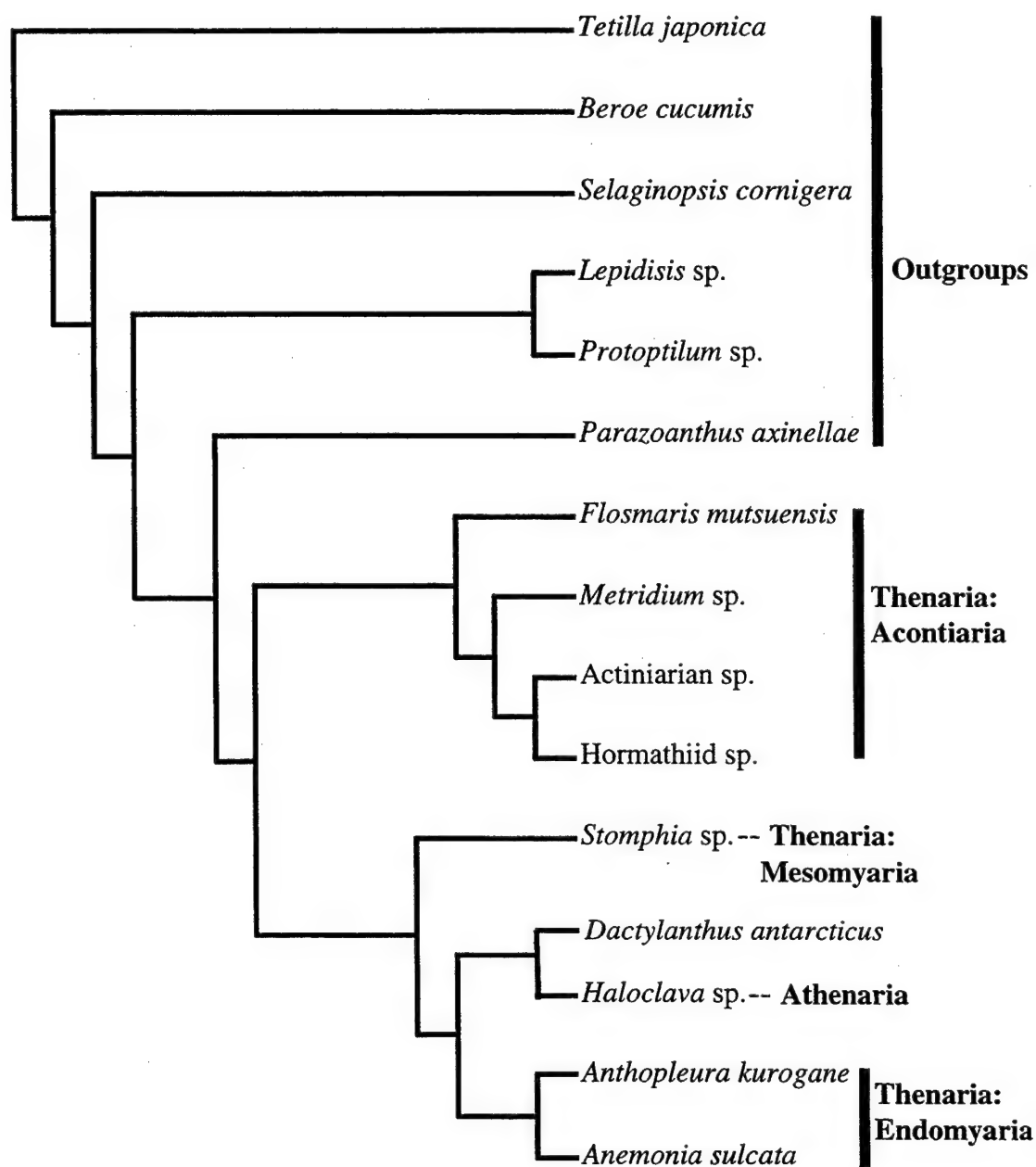
Fig. 6 **Maximum likelihood analysis of Actiniaria and Ptychodactiaria**
(*Dactylanthus antarcticus*) **(-Ln likelihood = 6094.807).** *Dactylanthus*
does not appear to constitute a separate order. It is most closely allied
with the tribe Athenaria (Suborder Nynantheae). Tribe Athenaria
and *Dactylanthus* branch within the clade of the Tribe Thenaria
(Suborder Nynantheae).

mesenteries. Their skeleton (if present) may be composed of calcium carbonate or chitin, but never contains free sclerites (Wells & Hill 1956a).

Molecular information from three different ribosomal genes have indicated two potential phylogenetic positions for the Ceriantharia within the Anthozoa. France et al. (1996) examined the mitochondrial 16S rRNA gene (550-900 bp from 29 species), and found the cerianthids were ancestral to the remaining hexacorals (Fig. 1a). A combination of 16S mtDNA and 18S rDNA sequences also found the cerianthids to be basal to the hexacorals (Bridge et al. 1995). A third study using 800 bp of the 18S rDNA from 13 species (Song & Won 1997) placed the cerianthid species as ancestral to all of the Anthozoa (Fig. 1b), as did a fourth study using 225 bp of 28S rDNA sequence from 22 species (Chen et al. 1995) (Fig. 1c).

The most likely tree generated from the 18S rDNA sequences in the present study did not support the alliance of the orders Ceriantharia and Antipatharia within the Subclass Ceriantipatharia (Fig. 1). Similar conclusions were found previously by France et al. (1996) and Song/Won (1997). The Ceriantharia appeared to be ancestral to the Hexacorallia, and the Antipatharia fell within the Hexacorallia. These analyses could not, however, identify the exact position of the Ceriantharia with statistical certainty (Fig. 3). The cerianthid species could be placed in multiple positions on the tree without reducing the likelihood of the tree significantly. These analyses of 18S sequence information were unable to establish the phylogenetic history of the Ceriantharia reliably.

I was able to clearly establish the affinities of the Order Antipatharia within the Subclass Hexacorallia from my analyses. Sequence analyses in the past have had incomplete sampling for the determination of the phylogenetic affinities of the Antipatharia. France et al. (1996) and Song and Won (1997) found the Antipatharia to be a sister clade to the Actiniaria, but neither study included zoanthid species in their analyses. The most likely tree from my analyses indicated the Antipatharia form a sister clade to the Zoanthidea.

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Moving the Antipatharia to branch with the Actiniaria, however, did not make the tree significantly less likely. A phylogenetic association between the Antipatharia and either the Zoanthidea or the Actiniaria was supported from these analyses.

The most likely tree generated from my 18S sequence data suggested that the Corallimorpharia were not monophyletic, and they exhibited a closer affinity to the Scleractinia than the Actiniaria (Fig. 5). This result agreed with the France et al. (1996) study (Fig. 1a), but not with Chen et al. (1995) (Fig. 1c). The latter showed the Actiniaria to be a polyphyletic group comprised of two clades, with species of Corallimorpharia branching with both clades of actiniarian species. These two actiniarian/corallimorpharian clades were distinct from the monophyletic clade of scleractinians. My most likely tree indicated that both the Actiniaria and the Scleractinia were monophyletic, and the Corallimorpharia branched basally to the Scleractinia. The Corallimorpharia could be moved throughout the scleractinian clade, however, without reducing the likelihood of the tree (KH Test, $P<0.05$). The likelihood of the tree was also not reduced significantly if the corallimorpharian species were forced to monophyly. The close phylogenetic association of the Corallimorpharia and the Scleractinia is reminiscent of the taxon Madreporaria (Stephenson 1921), in which were combined the Scleractinia and the Corallimorpharia. The close genetic affinity of the Scleractinia and the Corallimorpharia suggests that the morphological characters of mesentery structure, which is similar between the two groups, may be more reflective of evolutionary associations than the presence or absence of a skeleton.

The branching pattern of the Actiniaria in the present study differed from that found by Chen et al. (1995). I included representatives of the actiniarian taxa that branched with the Corallimorphidae in the 28S tree, but they fell with the other Actiniaria and not with the Scleractinia according to my 18S data. The polyphyly of the Actiniaria found by Chen et al. may have been a result of the short sequence length used for their analyses.

My taxonomic sampling is limited for the Corallimorpharia, but I chose species that represented both of the major morphotypes within the order: *Discosoma* is of the tropical, plate-like variety, and *Corynactis* is of the temperate, polyp-like variety. This sampling scheme is clearly insufficient for indicating relationships among the families of the Corallimorpharia, and as I have shown the 18S rRNA gene may also be inadequate for distinguishing the relationships within this group. The close relationship between the Scleractinia and the Corallimorpharia is evident, but the phylogenetic information present in these 18S sequences is insufficient to establish the specific relationships among these two groups.

My 18S rDNA data indicated that the Ptychodactiaria have strong connections to the Actiniaria. These data do not support the establishment of a separate order, although the possibility a separate order is warranted cannot be strongly rejected. I conducted an ML analysis on the Actiniaria and *Dactylanthus* alone, with a selection of species as the outgroup, and new parameters appropriate to these taxa. My analyses indicated good agreement between the 18S-generated relationships and traditional placement of *Dactylanthus* within the Actiniaria (Fig. 6). The subtribes each constituted monophyletic groupings. The Tribe Anthenaria, represented here by a single species, appeared to be derived from the Tribe Thenaria. The most likely tree from my analysis of this subset of species showed a sister-taxon relationship between *Dactylanthus* and *Haloclava*, of the Tribe Athenaria. However, *Dactylanthus* could be moved throughout the Endomyaria/Athenaria clade, or to a position basal to the Acontiaria, or basal to the Actiniaria as a whole without reducing the likelihood significantly (KH Test, $P<0.05$). This sampling scheme also lacks representatives of the two remaining suborders within the Actiniaria (Suborder Protantheae and Suborder Endocoelantheae). Thus, although the association of *Dactylanthus* with the Actiniaria is clear, its exact position within the Actiniaria remains unresolved.

These 18S sequence information confirmed the divergence between *Dendrobrachia* and the Antipatharia, the order in which it was originally placed (Fig. 5). *Dendrobrachia paucispina* fell securely within the octocorals, specifically with two species of the Suborder Holaxonia (*Lepidisis* sp. and *Narella bowersi*), and the unusual pennatulacean *Umbellula* sp.. Opresko and Bayer (1991) stated that *Dendrobrachia* is clearly an octocoral, based on its definitively gorgonian polyp structure. Although the genus has a spiny, chitinous skeleton and lacks free sclerites, these are the only characters shared with the Antipatharia. Opresko and Bayer (1991) suggested that *Dendrobrachia* may be associated with the Family Chrysogorgia, which is also within the Suborder Holaxonia, and my analyses were consistent with this hypothesis. It appears the skeletal composition is less important than polyp morphology for indicating taxonomic affinities for this group. A more comprehensive discussion of the phylogenetic position of *D. paucispina* appears in Chapter 4.

Conclusions

These analyses of 18S rDNA data indicate that the three-subclass system as it exists currently is not reflective of the evolutionary history of the Anthozoa. A three-subclass system may indeed be accurate, with the Ceriantharia designated a subclass with the Hexacorallia and the Octocorallia. The orders Ceriantharia and Antipatharia, united currently within the Subclass Ceriantipatharia, however, are genetically disparate groups. My data support the hypothesis that the Order Ceriantharia is ancestral to the Subclass Hexacorallia, while the Antipatharia are sister-taxa to the Zoanthidea and are highly derived within the Hexacorallia (as from Brook 1889, Hickson 1906, and Hadzi 1963). Although the most likely tree supports this conclusion, I cannot reject alternate hypotheses for the placement of the Ceriantharia as ancestral to the Anthozoa (as shown by Song & Won 1997). The phylogenetic affinities of the Ceriantharia could not be determined reliably

using these data. It is clear that they are highly divergent from the remaining Anthozoa, but their ancestry remains uncertain.

The Subclass Octocorallia, as well as the orders Actiniaria, Scleractinia, Zoanthidea, Ceriantharia, and Antipatharia were each well-supported monophyletic groupings. The Order Corallimorpharia did not appear to be monophyletic, however, and my results show that its affinities lie with the scleractinians. The internal mesentery structure appears to be a better character than the presence of a skeleton for indicating evolutionary patterns of the Corallimorpharia. This was suggested with the historical association of the Scleractinia and the Corallimorpharia within the Madreporaria, separate from the Actiniaria. Sequence information from genes with higher levels of divergence, as well as from additional species of Corallimorpharia, will likely be necessary to establish the relationships between the Corallimorpharia and the Scleractinia.

The phylogenetic affinities of the Ptychodactiaria and the genus *Dendrobrachia*, both of which have been equivocal, were established using 18S sequence information. The ptychodactiarian *Dactylanthus* was not genetically distinct from the Actiniaria, a result which is consistent with their original familial designation within the Actiniaria. My sequence information suggested an association of *Dactylanthus* with the Tribe Athenaria, but a more specific classification will require further sampling within the Actiniaria.

Sequence information showed that *Dendrobrachia* was allied with the Octocorallia, as has been predicted from recent morphological work. My analyses placed *Dendrobrachia* closest to members of the Suborder Scleraxonia and the pennatulacean *Umbellula*. Again, further analyses including a more complete representation of the octocorals will be necessary to firmly establish its phylogenetic position within the subclass.

This study has provided the most complete analysis of relationships across the Anthozoa to date. I have used the full 18S rDNA sequence for 38 species across all extant orders, and have conducted Maximum Likelihood techniques employing appropriate

models of evolution for this gene. Nuclear 18S sequence data have clearly shown the major divisions within the Anthozoa, and suggested phylogenetic affinities for species that had been enigmatic. Sequence information suggests that skeletal properties may not be a defining character indicating evolutionary relationships within the Anthozoa. Not all of the alternate hypotheses arising from other molecular studies can be supported or refuted with these data. Sequence information from additional genes and additional species will be necessary to establish the specific relationships investigated here.

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Chapter 4

Phylogenetic Relationships within the Subclass Octocorallia (Phylum Cnidaria: Class Anthozoa), Based on Nuclear 18S rRNA Sequence Information

Abstract

Historically, the Subclass Octocorallia was divided into seven orders: Helioporacea (Coenothecalia), Protoalcyonaria, Stolonifera, Telestacea, Alcyonacea, Gorgonacea, and Pennatulacea. It has been argued that this arrangement exaggerates the amount of variability present among the species of the Octocorallia. The current taxonomy recognizes the two orders of Helioporacea (blue corals) and Pennatulacea (sea pens), and assembles the remaining species into a third order, Alcyonacea. The species within the Alcyonacea exhibit a gradual continuum of morphological forms, making it difficult to establish concrete divisions among them. The subordinal divisions within the Alcyonacea correspond loosely to the traditional ordinal divisions. In this study I used molecular techniques to address the validity of the historical ordinal divisions and the current subordinal divisions within the Subclass Octocorallia. I also explore the phylogenetic affinities of the species *Dendrobrachia paucispina*, which was originally classified in the Order Antipatharia (Subclass Ceriantipatharia). Polyp structure indicates a closer affinity between *Dendrobrachia* and the Subclass Octocorallia. I have determined the nuclear 18S rRNA sequences for 41 species of octocorals, and use these to construct a molecular phylogeny of the subclass. I utilize Maximum Likelihood techniques, employing a realistic model of evolution for these species and this data set. The most likely trees from these sequence data indicate three clades, and do not support the morphological taxonomy of the Octocorallia. The Order Pennatulacea is the most cohesive group within the subclass, but is not monophyletic. One clade is undifferentiated and contains half of the species in this analysis. The third clade contains members from three suborders of the Alcyonacea, and one member of the Pennatulacea. These data cannot be used to distinguish among the branching order of these three clades. The morphological character of dimorphism (the presence of both autozooids and siphonozooids within a single colony) corresponds

loosely with the topology of the most likely trees, and the monophyly of dimorphism cannot be rejected from these data. The species *Dendrobrachia paucispina* has a close affinity with the genera *Corallium* and Paragorgia (Alcyonacea: Scleraxonia), although its morphology suggests it is more similar to the genus *Chrysogorgia* (Alcyonacea: Holaxonia). The genetic divergence found within genera is approximately equivalent to that found in other invertebrates, but the divergence found within families is greater in the octocorals than in other invertebrates. This difference may reflect the inappropriate inclusion of evolutionarily divergent genera within octocorallian families. I have employed appropriate evolutionary models for maximum likelihood analyses in this study, utilizing complete 18S rDNA sequences from the majority of families within the Octocorallia. Many of the relationships within the Octocorallia, however, remain ambiguous.

Introduction

The Subclass Octocorallia (Phylum Cnidaria) contains many well-known species of invertebrates, including soft corals, gorgonians, sea pens, and blue corals. They are exclusively polyp-shaped, and constitute a well-defined morphologic group. Several characters unite them: nematocyst structure, tentacle number and structure, and the number and structure of their mesenteries (divisions within the gastrovascular cavity). The octocorals are relatively simple taxa morphologically, however, with few remaining characters with which to distinguish taxonomic groupings within this subclass. They can be solitary or colonial, and may possess a skeleton consisting of a calcium and/or chitinous axis and extra-skeletal calcium-carbonate spicules. The axial structure and the spicular size, structure and arrangement are particularly useful for distinguishing among groups at all taxonomic levels within the octocorals. Other characters which are used to determine taxonomic groupings include the distribution of polyps and the budding pattern of new polyps, monomorphic vs. dimorphic colonies (autozooids and siphonozooids within the

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same colony), and the nature and arrangement of the calcium-carbonate spicules (Bayer 1956). The taxonomic characters available are so few that entire groups may have been defined based solely on a single characteristic (Hickson 1930). The fossil record for these species is also incomplete, contributing little towards the reconstruction of their evolution.

The traditional taxonomy for the Octocorallia divides the subclass into seven orders: Helioporacea (Coenothecalia), Protoalcyonaria, Stolonifera, Telestacea, Alcyonacea, Gorgonacea, and Pennatulacea (Fig. 1A). Morphology, however, distinguishes only two unique groups within the Octocorallia: the orders Helioporacea (blue corals) and Pennatulacea (sea pens) (Bayer 1956, Bayer 1973). The Helioporacea lack spicules, and form a massive crystalline aragonite skeleton, similar to some Hydrozoa and Scleractinia. The Pennatulacea are colonial and are dimorphic. The primary axial polyp is elongated and anchored into soft sediment, and the secondary autozooids branch from these primary polyps. Pennatulaceans are the most advanced in terms of their colonial complexity, functional specialization of zooids, and colonial integration (Bayer 1973).

The remaining species within the subclass are less easily classified based on morphology. One group of families (Ellisellidae, Ifalukellidae, Chrysogorgiidae, and Primnoidae) within the original Order Gorgonacea (Suborder Holaxonia) is clearly distinct from the remaining alcyonaceans based on its complete lack of chambered axial medulla. These families are sometimes grouped together as the 'restricted Holaxonia' (Bayer 1981). Firm divisions among the remaining species cannot be made on the basis of morphology. All degrees of colonial organization and skeletal form occur in a nearly uninterrupted continuum, and all of the major body plans are linked by intermediate forms that make strict morphological divisions difficult (Bayer 1973, Bayer 1981).

Although traditional taxonomy recognizes seven distinct orders, several species form morphological links between these groups: species of *Telestula* that were originally assigned with *Clavularia* link the Stolonifera and the Telestacea; *Protodendron repens* and

Subclass Octocorallia
    Order Helioporacea
    Order Protoalcyonaria
    Order Stolonifera
    Order Telestacea
    Order Alcyonacea
    Order Gorgonacea
    Order Pennatulacea

A

Subclass Octocorallia
    Order Helioporacea
    Order Alcyonacea
        Suborder Protoalcyonaria
        Suborder Stolonifera
        Suborder Alcyoniina
        Suborder Scleraxonia
        Suborder Holaxonia
    Order Pennatulacea

B

Fig. 1   **Taxonomic classifications of the Subclass Octocorallia.**
    A) Traditional classifications, e.g. Deichmann (1936), Hyman (1940).
    B) Revised classifications, from Bayer (1981).

Maasella radicans combine attributes of the Stolonifera and the Alcyonacea; the families Paragorgiidae and Briareidae have been assigned alternately to the Alcyonacea and Gorgonacea; species of *Keroeides*, *Lignella*, and *Ideogorgia* exhibit both the proteinaceous cross-chambered axis of the Holaxonia and the axial sclerites typical of the Scleraxonia (Bayer 1981). Bayer (1981) suggested that the amount of variation among these species was insufficient to warrant distinction at the ordinal level, and revised the classification accordingly. The orders Helioporacea and Pennatulacea were retained, and the remaining groups were established as suborders (listed with increasing level of colonial complexity) within the Order Alcyonacea (Fig. 1B). The remainder of the present paper will use Bayer's classification system as the reference.

The origins of the Octocorallia and their subsequent evolution remain to be determined, although the ancestral octocoral was likely solitary (Bayer 1973). The Pennatulacea are thought to be a very old group, however, although their precise origins are unclear. Pennatulacean-like species have been discovered from the Precambrian, preceding the appearance of any known gorgonian species (Bayer 1955, Bayer 1973). The Pennatulacea share morphological similarities with a number of alcyonacean species. Hickson (1916) suggested that the pennatulid Family Veretillidae may be the most primitive of the sea pens, and noted a similarity between the veretillids and a species of *Sarcophytum*, renamed *Anthomastus* (Alcyonacea: Alcyoniidae). The pennatulacean axial structure also has similarities to those of the gorgonian families Ellisellidae and Isididae, in patterns of chitinous and calcareous material extending outward from a calcareous core (Bayer 1955). Alternatively, the pennatulaceans may have arisen from a *Telesto*-like ancestor, the colony morphology of which superficially resembles that of the Pennatulacea (Bayer 1956, Bayer 1973). In 1900, Bourne proposed uniting the Pennatulacea and the Telestacea into a single group (cited in Hickson 1916). The lack of any known

morphological intermediates between the Pennatulacea and the other members of the subclass makes it difficult to establish evolutionary pathways.

In this study I utilized 18S rRNA molecular sequences to examine phylogenetic relationships within the Subclass Octocorallia. Molecular sequences can be used as additional characters, and can be useful for suggesting relationships among taxa with few morphological characters. The nuclear 18S rRNA gene has been useful in addressing questions on a variety of evolutionary scales, including relationships at the ordinal level, (e.g. Kelly-Borges et al. 1991, Hay et al. 1995) and the family level (e.g. Kuznedelov & Timoshkin 1993, Fitch et al. 1995).

The present phylogenetic analyses were based on complete 18S rDNA sequences from 41 species of octocorals, plus partial sequences for three additional species. I utilized Maximum Likelihood (ML) techniques, employing an evolutionary model applicable to the gene and organisms included in this study (Swofford et al. 1996, Huelsenbeck & Crandall 1997). It is particularly important to use realistic evolutionary algorithms when including this many taxa and basepairs. The amount of error introduced into an analysis through the use of inappropriate models may overwhelm the phylogenetic information contained in the data set (DeSalle et al. 1994, Rzhetsky & Nei 1995).

The specific goals of this study were to examine the primary phylogenetic groupings within the Subclass Octocorallia. I explored the genetic divisions within the Subclass Octocorallia with three primary inquiries: 1) is there molecular support for the either the historical ordinal divisions, or the subordinal divisions as they stand today, 2) is there genetic evidence for distinct divisions for the Helioporacea and Pennatulacea, and 3) is there any support for the ancestral nature of the Pennatulacea? The levels of genetic differentiation measured among groups was compared between orders within the Subclass Octocorallia and the Subclass Hexacorallia (Phylum Cnidaria). The hexacorals are likely appropriate models because they are closely related species, and their orders are fairly well

defined both on a morphological and a molecular level (Berntson et al. in prep). Traditional morphological characters were compared phylogenetic groupings found to evaluate which ones appeared to provide the most taxonomic information.

The final portion of this study examined the phylogentic affinities of the intriguing species *Dendrobrachia paucispina*. This genus was originally classified with the Order Antipatharia (black corals) based on its chitinous, spiny axis and its lack of sclerites. A thorough examination of the polyp structure was not possible at that time due to poor sample preservation (Brook 1889). Even without information on polyp morphology, Brook (1889) noted similarities in the axial structure between *Dendrobrachia* and the Order Gorgonacea, but *Dendrobrachia* was placed with the Antipatharia because it lacked free sclerites. Recent morphological studies of this genus have determined that the polyp structure places *Dendrobrachia* unequivocally within the Subclass Octocorallia, specifically with members of the Family Chrysogorgiidae (Alcyonacea: Holaxonia) (Opresko & Bayer 1991). Our previous work with 18S rDNA sequence information (Berntson et al. in prep) suggested that *Dendrobrachia* has phylogenetic affinities with the octocorals, although our sampling at that time was insufficient to suggest its familial position. The present study provides sequences from all of the ordinal and subordinal groups within the Octocorallia, including 22 of the 30 extant families of Alcyonacea. This level of sampling was designed to determine whether *Dendrobrachia* was most closely related to the Chrysogorgiidae as predicted from morphology.

Methods

Specimens

The species used in this study (Table 1) were obtained from several sources. Forty sequences were determined for this work, and 13 additional sequences (including outgroups) were taken from Genbank. Ten of the octocoral specimens and the specimen of

Table 1   Specimens used in phylogenetic analyses.   Species of Placozoa, Porifera, Ctenophora, Hydrozoa and Cubozoa were used as outgroups.   ID# refers to museum accession numbers or to collection number.   Specimen sources are as follows: AJ, courtesy of Ardis Johnston and the Harvard Museum of Comparative Zoology; Bishop Seamount, 18.8°N 159.1°W; CG courtesy of Constance Gramlich, University of California, San Diego; Cross Seamount, 18.7°N 158.3°W; Fieberling Guyot, 32.1°N 127.8°W; Pensacola Seamount, 18.3°N 157.3°W; NMNH, provided by Dr. Frederick Bayer, National Museum of Natural History, Smithsonian; TG, courtesy of Tamar Goulet, State University of New York, Buffalo.

Species	Source	ID #	Genbank Acc. #
Phylum Porifera			
Class Calcarea			
Scypha ciliata	Genbank		D15066
Class Demospongiae			
Tetilla japonica	Genbank		D15067
Phylum Ctenophora			
Mnemiopsis leidyi	Genbank		L10826
Beroe cucumis	Genbank		D15068
Phylum Placozoa			
Trichoplax sp.	Genbank		Z22783
Phylum Cnidaria			
Class Hydrozoa			
Selaginopsis cornigera	Genbank		Z92899
Class Cubozoa			
Tripedalia cystophora	Genbank		L10829
Class Anthozoa			
Subclass Hexacorallia			
Order Actiniaria			
Suborder Nynanthea			
Tribe Thenaria			
Subtribe Endomyaria			
Fam. Actiniidae			
Anemonia sulcata	Genbank		X53498
Subtribe Acontiaria			
Fam. Hormathiidae			
Hormathiid sp.	Fieberling Guyot, 640 m	AD2294-2	AF052890
Subclass Octocorallia			
Order Helioporacea			
Family Helioporidae			
Heliopora coerulea (partial)	Aru Island, Indonesia, 1 m; NMNH	79529	AF052923

Taxon	Location	Accession
Order Alcyonacea		
Suborder Protoalcyonaria		
Family Taiaroidae		
Taiaroa tauhou	Otago Penninsula, NZ, 420-320 m[NMNH]	AF052908
Suborder Stolonifera		
Family Clavulariidae		
Clavularia sp.	Mission Bay, CA, 8 m[CG]	AF052938
Family Telestidae		
Telestula sp.	Kaena Point, Oahu, HI, 558 m	AF052914
Family Tubiporidae		
Tubipora musica	Bikini Atoll, Marshall Islands[NMNH]	AF052909
Family Coelogorgiidae		
Coelogorgia palmosa (partial)	Aldabra, Seychelles, 60-80 ft[NMNH]	AF052932
Suborder Alcyoniina		
Family Alcyoniina		
Family Alcyoniidae		
Alcyonium gracillimum	Genbank	Z92902
Anthomastus sp.	Keanapapa Pt., Lanai, HI, 1226 m	AF052881
Bellonella rigida	Genbank	Z49195
Protodendron sp.	Fieberling Guyot, 640 m	AF052921
Family Nephtheidae		
Lemnalia sp.	Gulf of Eilat, Red Sea[TG]	AF052924
Family Nidaliidae		
Siphonogorgia sp.	Augulpelu Island, Palau, 110 ft[NMNH]	58584
Family Xeniidae		AF052927
Xenia sp.	Gulf of Eilat, Red Sea[TG]	AF052931
Suborder Scleraxonia		
Family Briareidae		
Briareum asbestinum	San Blas Islands, Panama[TG]	AF052912
Family Anthothelidae		
Anthothela nuttingi	Cross Seamount, HI, 1010 m	AF052922
Erythropodium caribaeorum	San Blas Islands, Panama[TG]	AF052915
Family Paragorgiidae		
Paragorgia sp.	Fieberling Guyot, 490 m	AF052917
Family Coralliidae		
Corallium kishinouyei	Cross Seamount, HI, 1145 m	AF052918
Corallium cf. *ducale*	Cross Seamount, HI, 1370 m	AF052919

Additional notes: CR106-1 (Cross Seamount, HI, 1010 m), AD2301-1 (Fieberling Guyot, 490 m), CR105-1, NMNH 94462; CR202-2, OAS-28, LAD-64, AD2321-8, 79459, 75637, 54271

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Taxon	Locality	Collection no.	Accession
Family Melithaeidae			
Melitella sp.	Okinawa Archipelago, Japan, 16 m[AJ]	OK1078KM	AF052929
Suborder Holaxonia			
Family Acanthogorgiidae			
Calicgorgia spiculifera	Aleutian Islands, 431 m[NMNH]	not. cat.	AF052925
Acanthogorgia sp.	Bishop Seamount, HI, 1295 m	BI104-3	AF052907
Family Plexauridae			
Eunicea laciniata	Antigua, Caribbean Sea, 30 ft[NMNH]	73614	AF052926
Calicogorgia granulosa	Genbank		Z92900
Euplexaura crassa	Genbank		Z92901
Paramuriceid sp.	Cross Seamount, HI, 1145 m	CR105-5	AF052920
Family Gorgoniidae			
Lophogorgia chilensis	Santa Catalina Island, CA, ~15 m		AF052928
Family Ellisellidae			
Junceella sp.	Guam[TG]		AF052936
Junceella racemosa	Okinawa, Japan, 45 m[NMNH]	92412	AF052937
Family Ifalukellidae			
Plumigorgia hydroides (partial)	S. Satawan, Micronesia Chuuk, 30 m[AJ]	OCDN02224	AF052930
Family Chrysogorgiidae			
Chrysogorgia chryseis	Cross Seamount, HI, 1010 m	CR106-2	AF052913
Family Dendrobrachiidae			
Dendrobrachia paucispina	Great Australian Bight, 884-859 m[NMNH]	87768	AF052903
Family Primnoidae			
Narella nuttingi	Cross Seamount, HI, 1350 m	CR203-1	AF052881
Narella bowersi	Pensacola Seamount, HI, 1350 m	PN105-3	AF052905
Family Isididae			
Lepidisis sp.	Pensacola Seamount, HI, 1425 m	PN104-1	AF052906
Orstomisis crosnieri	New Caledonia, 600 m[NMNH]	84774	AF052916

Taxon	Locality	Voucher	GenBank
Order Pennatulacea			
Suborder Sessiliflorae			
Family Anthoptilidae			
Anthoptilum cf. *grandiflorum*	Keanapapa Pt., Lanai, HI, 1226 m	LAD-35	AF052933
Family Protoptilidae			
Protoptilum sp.	Bishop Seamount, HI, 1440 m	BII01-3	AF052911
Family Renillidae			
Renilla reniformis	Mission Bay, CA, 8 m	CG	AF052581
Family Umbellulidae			
Umbellula sp.	Bahamas, 1447 m	NMNH	AF052904
Suborder Subselliflorae			
Family Pennatulidae			
Leioptilus fimbriatus	Genbank	54597	Z92903
Family Virgulariidae			
Stylatula sp.	Mission Bay, CA, 8 m	CG	AF052934
Virgularia sp.	Mission Bay, CA, 8 m	CG	AF052935
Acanthoptilum sp.	Mission Bay, CA, 8 m	CG	AF052910

Dendrobrachia paucispina were acquired from Dr. Frederick Bayer of the National Museum of Natural History and Ardis Johnston of the Harvard Museum for Comparative Zoology. These specimens had been stored in ethanol for periods ranging from two to 50 years. No information was available as to whether the samples were fixed originally in ethanol or in formalin. Fresh specimens of octocorals and Actiniaria were collected by submersible from Hawaiian seamounts (using the Pisces V submersible, operated by the Hawaiian Undersea Research Laboratory at the University of Hawaii) and Fieberling Guyot (using the Alvin submersible, operated by the Woods Hole Oceanographic Institution). The specimens collected from these dives were frozen in liquid nitrogen or frozen at -20°C. Other octocoral specimens were collected in US waters by snorkeling or SCUBA. DNA extractions of several octocorals were donated by Dr. Tamar Goulet of the State University of New York, Buffalo.

DNA Extraction Protocol

The extraction protocols were based on those described by Coffroth et al. (1992) and Winnepenninckx et al.(1993). Five to ten polyps of fresh or frozen tissues were minced with a razor blade and placed in a 1.5-ml eppendorf tube with 600 µl of 2X cetyltrimethylammonium bromide (CTAB) buffer ((1.4M NaCl, 0.02M EDTA, 0.1M Tris-HCl (pH 8.0), 2% CTAB (Sigma Chemical Co.), and 0.2% beta-mercaptoethanol)). A plastic dounce was employed to further shear the tissue, and an additional 300 µl of 2X CTAB was added. The samples were placed at 55°C and digested with 5 µl of proteinase K (20 mg/ml) for approximately two hours. The tissues were extracted once with an equal volume of 24:1 chloroform:isoamyl alcohol, and precipitated in two volumes of cold 95% ethanol at -20°C overnight. The tubes were centrifuged at 10,000xg for 30 minutes, and the ethanol was removed. The pellets were washed in 500 µl cold 70% ethanol, and the tubes were centrifuged at 7,000xg for 15 minutes. The ethanol was removed, and the

pellets dried at room temperature. The pellets were resuspended in 50 µl of TE buffer (10 mM Tris-HCl (pH 8.0), 1 mM EDTA (pH 8.0)) and placed at 4°C for three to four hours before visualization on an agarose gel.

The DNA extraction protocol for the archival specimens differed slightly. Five to ten polyps of the ethanol-stored specimens were placed on ice in 2 to 10 ml 2X CTAB buffer for up to 24 hours, with the buffer replaced several times during this period. The buffer was removed, and the tissue minced finely with a razor blade as above. The tissues were incubated with proteinase K at 55°C for 24 hours, with periodic agitation. Another 5 µl of proteinase K was added, and the tissues continued to digest for an additional eight to twelve hours. The subsequent extraction procedure followed as above.

DNA Amplification Protocols

Pipet tips with a filter barrier were used throughout this process to guard against contamination of the reactions. Negative controls were included during the DNA extractions and PCR reactions to detect contamination if it did occur. Each extracted DNA sample was diluted 1:10 in TE buffer, and 2 µl of that dilution was used in a 50-µl PCR reaction. Modified versions of the universal eukaryotic primers A and B (with the polylinkers removed) from Medlin et al. (1988) were used in the initial DNA amplifications of the 18S rRNA gene. Primer sequences are as follows: A (forward) 5'-AACCTGGTTGATCCTGCCAGT-3', B (reverse)-- 5'-TGATCCTTCTGCAGGTTCACCTAC-3'. I found the 18S rRNA gene to be roughly 1800 basepairs (bp) in length in anthozoans. Thirty-five cycles of PCR were carried out using a Perkin Elmer Thermal Cycler 480. The DNA was denatured at 94°C for 45 seconds, the primers and template were annealed at 55°C for one minute, and the original DNA strand was extended at 72°C for 90 seconds. These 35 cycles were followed by a

five minute extension at 72°C. The product was visualized on a 1% agarose gel, and then prepared for TA-cloning.

For those archival specimens that yielded no visible PCR product, a second PCR reaction was conducted using 1 μl of product from the initial PCR reaction as the template. The amplified negative control (no DNA was added to the tube) from the initial PCR reaction was included in the second reaction, using 1 μl of the original negative control as template. The primers used for the second PCR reaction were chosen to insure that at least one primer annealed internally to the initial A and B primers. The internal primers were selected from a combination of universal eukaryotic primers and a set of octocoral-specific primers that I designed. The universal primers are the following: 373 (forward) 5-'GATTCCGGAGAGGGAGCCT-3' and 1200 (reverse) 5'-GGGCATCACAGACCTG-3' (Weekers et al. 1994), 514 (forward) 5'-GTGCCAGCMGCCGCGG-3', 1055 (forward) 5'-GGTGGTGCATGGCCG-3', and 1055 (reverse) 5'-CGGCCATGCACCACC-3' (Elwood et al. 1985), and 536 (reverse) 5'-WATTACCGCGGCKGCTG-3' (Lane et al. 1985). The taxon-specific primers were designed to amplify anthozoan DNA, but not DNA from the potential contaminants. The octocoral-specific primers were designed from alignments of GenBank sequences of actiniarians (listed in Table 1), two fungi (*Cryptococcus neoformans*, GenBank Accession #L05428, and *Bullera unica*, #D78330), potential epibionts from Mollusca and Crustacea (*Mytilus galloprovincialis*, #L33451, and *Stenocypris major*, #Z22850), and a zooxanthella symbiont (*Symbiodinium* sp., #M88509). Octocoral sequences derived from frozen tissue in this lab (Table 1) were verified as cnidarian through a BLAST search of GenBank and were also used in the primer design. Octocoral-specific primer sequences are the following: 705 (forward) 5'-GGTCAGCCGTAAGGTTT-3', 705 (reverse) 5'-CATACCTTTCGGCTGACC-3', 900 (forward) 5'-GTTGGTTTTTTGAACCGAAG-3', 900 (reverse) 5'-CTTCGGTTCTAGAAACCAAC-3', 1560 (reverse) 5'-GGTGAAGGAGTTACTCGATG-

3'. PCR primer pairs were chosen to include at least one octocoral-specific primer, and to amplify the largest fragment possible from the archival specimens. Further details and the rationale behind this technique are described elsewhere (Berntson & France in prep).

Determination of DNA Sequences

The final PCR product was cloned using the Original TA Cloning Kit (Invitrogen Corporation). The PCR product was ligated into the pCR 2.1 cloning vector, then transformed into a strain of INVαF' cells. The plasmid was isolated using the Wizard Miniprep DNA Purification Kit (Promega Corporation) and subsequently used as a template for cycle sequencing reactions, using the SequiTherm EXCEL Long-Read DNA Sequencing Kit-LC (Epicentre Technologies). DNA sequences were determined for both the forward and reverse strands of the gene. The reactions were run on a LI-COR 4000 DNA Sequencer, using infrared-labeled primers: M13 (forward) 5'-CACGACGTTGTAAAACGAC-3', M13 (reverse) 5'-GAATAACAATTTCACACAGG-3', 514 (forward) 5'-TCTGGTGCCAGCASCCGCGG-3', 536 (reverse) 5'-TGGWATTACCGCGGSTGCTG-3', 1055 (forward) 5'-GTGGTGGTGCATGGCCG-3', 1055 (reverse) 5'-AAGAACGGCCATGCACCAC-3'. The resulting images were interpreted using the BioImage gel reader program.

Sequence Analysis

DNA sequences were aligned first by eye, taking into account secondary structure models, and with the alignment program Clustal W 1.6 (Thompson et al. 1994). Regions of uncertain alignment were eliminated from the final analyses (the nexus file is available upon request). In total, 1640 basepairs were used in the analyses, of which 413 out of 689 variable sites were parsimony-informative, and 276 were parsimony-uninformative.

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All analyses were performed using test versions of PAUP* (versions 4d61 and 4d63) written by David Swofford (Swofford 1996, betatest version). An initial parsimony analysis of the entire dataset was performed, which resulted in 35,000 equally parsimonious trees. The likelihood scores were calculated for one of the most parsimonious trees, using a variety of evolutionary models. The purpose for this procedure was to identify the simplest model of evolution that was still accurate for this data set; the simpler model will have a lower variance (Rzhetsky & Nei 1995) and will be less computationally intensive. Using the Likelihood Ratio Test (LRT) as described by Huelsenbeck and Rannala (1997), the likelihood scores were calculated for each ML model and compared to the most complex model, which is a general time-reversible (GTR) model incorporating unequal base frequencies and among-site substitution heterogeneity. The values of the LRT are approximately chi-square distributed, with the degrees of freedom equal to the difference in free parameters between the models being tested. Models for which the LRT score was greater than the Chi-square critical value were rejected as not being sufficiently accurate.

A strict consensus tree from the initial parsimony search was calculated, and it indicated a large undifferentiated clade (data not shown). A bootstrap analysis using ML-based distance calculations was also performed, and the results showed strong support (bootstrap value = 91) for the existence of the same undifferentiated clade (Fig. 2). The topology of the taxa within this clade was fixed for subsequent analyses, based on one of the equally parsimonious trees found. This was done for computational reasons, as it effectively reduced the number of taxa in the analysis from 53 to 32. Without fixing this clade, much of the computational time would have been utilized by these taxa, for which there was very low phylogenetic signal.

The outgroups chosen for these analyses were two species from the Phylum Porifera, two species from the Phylum Ctenophora, one species from the Phylum

Fig. 2   **Bootstrap analysis using distances calculated with maximum likelihood parameters, showing the undifferentiated clade. Undifferentiated clade and outgroups identified by bars. Numbers at nodes are the percent that branch occurred in subsampled replicates. No taxa were fixed for this computation. Horizontal branch length does not reflect genetic distance among taxa.**

	86	*Corallium* c.f. *ducale*
	60	*Dendrobrachia paucispina*
100		*Corallium kishinouyei*
100		*Paragorgia* sp.
95		*Anthomastus* sp.
64		*Umbellula* sp.
100		*Narella nuttingi*
89		*Narella bowersi*
93		*Chrysogorgia chryseis*
100		*Lepidisis* sp.
		Orstomisis crosnieri
93		*Stylatula* sp.
		Virgularia sp.
65		*Acanthoptilum* sp.
		Renilla reniformis

Corallium c.f. *ducale*
Dendrobrachia paucispina
Corallium kishinouyei
Paragorgia sp.
Anthomastus sp.
Umbellula sp.
Narella nuttingi
Narella bowersi
Chrysogorgia chryseis
Lepidisis sp.
Orstomisis crosnieri
Stylatula sp.
Virgularia sp.
Acanthoptilum sp.
Renilla reniformis
Protoptilum sp.
Junceella sp.
Erythropodium caribaeorum
Junceella racemosa
Telestula sp.
Anthoptilum c.f. *grandiflorum*
Leioptilus fimbriatus
Alcyonium gracillimum
Heliopora coerulea
Coelogorgia palmosa
Plumigorgia hydroides
Paramuriceid sp.
Calcigorgia spiculifera
Melitella sp.
Siphonogorgia sp.
Anthothela nuttingi
Eunicea laciniata
Euplexaura crassa
Calicogorgia granulosa
Xenia sp.
Lemnalia sp.
Clavularia sp.
Lophogorgia chilensis
Tubipora musica
Protodendron sp.
Bellonella rigida
Taiaroa tauhou
Acanthogorgia sp.
Briareum asbestinum
Anemonia sulcata
Hormathiid sp.
Selaginopsis cornigera
Tripedalia cystophora
Trichoplax sp.
Beroe cucumis
Mnemiopsis leidyi
Scypha ciliata
Tetilla japonica

Undifferentiated clade

Outgroups

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Placozoa, four other species from the Phylum Cnidaria (one each from the classes Hydrozoa and Cubozoa, and two species of anemones, Class Anthozoa) (Table 1). These species were previously shown to be appropriate outgroups for phylogenetic analyses of the subclass divisions within the Anthozoa (Berntson et al. in prep). Five replicates of a ML analysis were performed using random addition of taxa to find the most likely trees given this data set. Trees were viewed using PAUP* and the free-ware program TreeView (Page 1996).

Likelihood scores were also used to test specific phylogenetic hypotheses relating to the questions addressed with this study. Alternative evolutionary hypotheses were formed by manipulating tree topologies using the computer program MacClade (Maddison & Maddison 1992). The Kishino-Hasegawa test (KH Test) (Kishino & Hasegawa 1989) within the PAUP* program was used to compare the likelihood scores of those topologies.

I compared genetic divergences within the Octocorallia to those found in the Hexacorallia, as well as to divergences measured in other invertebrates using 18S ribosomal sequences. I used PAUP* to calculate the basic percent divergence values (p-distance) and the ML-corrected distances, using the aligned and edited dataset. The divergences for the Hexacorallia were calculated from the data set from another study (Berntson et al. in prep).

Results

The results from the Likelihood Ratio Test (LRT) of the original parsimony tree showed statistically ($P<0.05$) that simple parsimony and distance models were insufficient to represent the evolution of this gene. The only appropriate model for the analysis of this data set was a General Time-Reversible (GTR) model with unequal base frequencies and among-site heterogeneity. All simpler models were statistically inferior to the full GTR model for explaining this tree, given these data. The parameters estimated from the

parsimony tree (Table 2) were used in a heuristic ML search consisting of five replicates, with random addition of sequences. The parameters were re-estimated using the most likely tree that was produced from that ML analysis, to insure there were no significant changes. The most likely trees were found within the first replicate in all analyses conducted.

Three equally likely trees were produced from the ML analysis, and a representative of these trees is shown (Fig. 3). Three distinct clades were evident within the Octocorallia, none of which corresponded to current taxonomy. The most likely trees differed in the branching order of the basal nodes separating the three clades. This branching order could not be resolved statistically with the present sequence information.

Members of most suborders were represented in all three clades. Clade A (Fig. 3) had the most phylogenetic structure within it, as indicated by bootstrap values associated with its topology (Fig. 2). Clade A (Fig. 3) contains primarily holaxonians (families Chrysogorgiidae, Isididae, and Primnoidae), but also members from the Scleraxonia, Pennatulacea, and Alcyoniina. Clade B contains the majority of the Pennatulacea, as well as members of the Stolonifera, Scleraxonia, and Holaxonia. Clade C is essentially undifferentiated, and contains members of all major groups except Pennatulacea. There is very little phylogenetic signal present within this clade.

The most likely trees provided support for the current taxonomy at the level of Family, for some of the families represented by multiple species. The families Ellisellidae, Isididae, and Primnoidae (Order Alcyonacea: Suborder Holaxonia) constituted monophyletic groups based on the species chosen here. The most likely tree showed the Coralliidae (Suborder Scleraxonia) to be paraphyletic, with the inclusion of the genus *Dendrobrachia*. *Dendrobrachia* could be placed as sister-taxon to the two species of *Corallium* without reducing the likelihood of the tree significantly (KH Test, P<0.05). The families Alcyoniidae (Order Alcyonacea: Suborder Alcyoniina), Anthothelidae (Order

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Sequence Parameter	Value
Base frequencies	
A	0.258
C	0.206
G	0.264
T	0.272
Substitution R matrix	
A/C	1.0257
A/G	2.6331
A/T	0.9627
C/G	1.3927
C/T	4.4228
Proportion of invariant sites	0.3761
Gamma distribution	
α	0.6455

Table 2   Sequence parameter values calculated from the 18S rDNA used in the present study. Values used as input for maximum likelihood analyses. The R matrix contains base-specific substitution rates. The gamma distribution parameter α is the inverse of the coefficient of variation of the substitution rate.

Fig. 3   One of three equally likely trees produced from maximum likelihood analyses, with the topology of species in clade C (circled) fixed (-Ln likelihood = 11129.976). The relative positions of nodes A, B and C are interchangeable and equally likely. Clades marked with vertical bars contain dimorphic species. Horizontal branch length reflects genetic distance among taxa. Colors represent the major taxonomic groupings within the Octocorallia. The seven species in black at the base of the tree are the outgroups.

Corallium c.f. *ducale*
Dendrobrachia paucispina
Corallium kishinouyei
Paragorgia sp.
***Anthomastus* sp.**
Umbellula sp.

Dimorphic

Narella nuttingi
Narella bowersi
Chrysogorgia chryseis
Lepidisis sp.
Orstomisis crosnieri

A

Acanthoptilum sp.
Renilla reniformis
Stylatula sp.
Virgularia sp.
Leioptilus fimbriatus
Protoptilum sp.
Anthoptilum c.f. *grandiflorum*
Junceella racemosa
Junceella* sp.
Telestula* sp.
Erythropodium caribaeorum

Dimorphic

B

Taiaroa tauhou
Heliopora coerulea
Tubipora musica
Lemnalia* sp.
Alcyonium gracillimum
Calcigorgia spiculifera
Eunicea laciniata
Siphonogorgia* sp.
Protodendron* sp.
Anthothela nuttingi
Paramuriceid sp.
Clavularia* sp.
Acanthogorgia* sp.
Lophogorgia chilensis
Calicogorgia granulosa
Euplexaura crassa
Bellonella rigida
Melitella* sp.
Plumigorgia hydroides
Xenia* sp.
Coelogorgia palmosa
Briareum asbestinum

C

-- Order Helioporacea
-- **Suborder Protoalcyonaria**
-- **Suborder Stolonifera**
-- Suborder Alcyoniina
-- **Suborder Scleraxonia**
-- **Suborder Holaxonia**
-- Order Pennatulacea

Hormathiid sp.
Anemonia sulcata
Tripedalia cystophora
Selaginopsis cornigera
Trichoplax* sp.
Beroe cucumis
Mnemiopsis leidyi
Scypha ciliata
Tetilla japonica

Outgroups

0.03

149

Alcyonacea: Suborder Scleraxonia), and Virgulariidae (Order Pennatulacea) did not appear to be monophyletic. The associations within the families Acanthogorgiidae and Plexauridae (Order Alcyonacea: Suborder Holaxonia) could not be determined from these data, as they fell within the undifferentiated clade C.

The morphologically well-defined groups within the Octocorallia were not well supported genetically. The majority of the species within the Order Pennatulacea branched with Clade B, but the genus *Umbellula* fell in Clade A, basal to *Anthomastus*. *Umbellula* could not be moved without reducing the likelihood of the tree significantly (KH Test, P<0.05). The remaining Pennatulacea formed a monophyletic clade, at the base of which fell species from three different suborders. The sole representative of the other well-defined group of octocorals, the Heliporacea, could not be distinguished from the undifferentiated Clade B. Its placement, however, may be an artifact resulting from an incomplete sequence (541 bp out of 1646 were used). The clear association of the 'restricted Holaxonia' was also not supported in these trees, as the four families were spread throughout all three clades.

Four taxa (*Erythropodium*, *Telestula*, and two species of *Junceella*) were found at the base of the pennatulacean clade in each of the three most likely trees (Fig. 3). The distinct morphology of the Pennatulacea does not predict a close association with these taxa. I tested the support for the placement of these four taxa with the Pennatulacea by constraining them into each of clades A and C, and performing an heuristic search for the most likely tree given each of the constraints. These four taxa could be placed at the base of either Clade A or Clade C without reducing the likelihood of the tree significantly (KH Test, P<0.05).

Dendrobrachia paucispina was closely affiliated with the genera *Corallium* and *Paragorgia*, with 100% bootstrap support (Fig. 2). *Dendrobrachia* could be moved to all

positions on the tree near *Paragorgia* and the two species of *Corallium* without reducing the likelihood of the tree significantly (KH Test, P<0.05).

The morphological character of dimorphism was found in two separate groups: the Pennatulacea, and the group containing *Umbellula, Anthomastus, Paragorgia,* and *Corallium* (Fig. 3). I forced monophyly of the dimorphic species to investigate the possibility that this character arose once within the Octocorallia. The resulting topology (Fig. 4) did not decrease the likelihood significantly from the best trees (KH Test, P<0.05). *Erythropodium, Telestula,* and the two species of *Junceella* in the previous paragraph could be moved to any of positions 1, 2, or 3 on this tree without reducing the likelihood significantly (KH Test, P<0.05).

The genetic divergences measured using *p*- and ML-distance calculations from these 18S sequence data showed similarities between the Hexacorallia and the Octocorallia, as well as with other invertebrates at the higher taxonomic levels (between classes within Cnidaria and orders within the Hexacorallia and Octocorallia) and at the lower levels (within genera). Divergences at the intermediate taxonomic levels (between suborders and within families) did not agree as closely between the Anthozoa and other invertebrates (Table 3). The ML-corrected distances were slightly greater than the *p*-distance values. The *p*-distance divergence between classes in the Phylum Cnidaria was approximately 6.8-15%, which is comparable to those values found among classes of echinoderms (6.0-12.2%) (Wada & Satoh 1994). The divergence among the orders within the hexacorals (1.5-8.1%) was similar to the divergence found between the octocorallian orders Pennatulacea and Alcyonacea (1.3-9.2%), and between the Helioporacea and the Alcyonacea (0.34-8.15%). The divergence within genera was approximately equivalent for hexacorals (0.5-1.07%) and octocorals (0.6-1.6%), although it was greater than that found in the bivalve mollusk *Mytilus* (0.1-0.6%) (Kenchington et al. 1995).

Fig. 4   The resulting likelihood tree when the dimorphic species are
constrained to a single clade (-Ln likelihood = 11153.843).
The topology of this tree is not significantly less likely than
the most likely tree (KH Test, P<0.05).   The species *Telestula*
sp., *Erythropodium caribaeorum*, *Junceella racemosa* and
Junceella sp. can be placed at positions 1, 2 or 3 without a
significant reduction in the likelihood of the tree (KH Test,
P<0.05).   The seven species in black at the base of the tree are
the outgroups.

Dimorphic

Acanthoptilum sp.
Renilla reniformis
Stylatula sp.
Virgularia sp.
Leioptilus fimbriatus
Protoptilum sp.
Anthoptilum c.f. *grandiflorum*
Corallium c.f. *ducale*
Dendrobrachia paucispina
Corallium kishinouyei
Paragorgia sp.
Anthomastus sp.
Umbellula sp.

1

Monomorphic

Taiaroa tauhou
Heliopora coerulea
Tubipora musica
Lemnalia sp.
Alcyonium gracillimum
Calcigorgia spiculifera
Eunicea laciniata
Siphonogorgia sp.
Protodendron sp.
Anthothela nuttingi
Paramuriceid sp.
Clavularia sp.
Acanthogorgia sp.
Lophogorgia chilensis
Calicogorgia granulosa
Euplexaura crassa
Bellonella rigida
Melitella sp.
Plumigorgia hydroides
Xenia sp.
Coelogorgia palmosa
Briareum asbestinum
Junceella racemosa
Junceella sp.
Telestula sp.
Erythropodium caribaeorum
Narella nuttingi
Narella bowersi
Chrysogorgia chryseis
Lepidisis sp.
Orstomisis crosnieri
Anemonia sulcata
Hormathiid sp.
Tripedalia cystophora
Selaginopsis cornigera
Trichoplax sp.

2

3

Outgroups

-- Order Helioporacea
-- **Suborder Protoalcyonaria**
-- **Suborder Stolonifera**
-- **Suborder Alcyoniina**
-- Suborder Scleraxonia
-- **Suborder Holaxonia**
-- Order Pennatulacea

Beroe cucumis
Mnemiopsis leidyi
Scypha ciliata

0.04

Tetilla japonica

Table 3 Genetic divergences measured from nuclear 18S rDNA. Values represent raw p-distances and maximum likelihood-corrected distances. Estimates were made from the aligned, edited data set.

Category	Taxa	P-distance (%)	ML distance (%)	Reference
Between classes	Cnidaria, without Ceriantharia	6.8-15.0	8.5-21.8	present study
	Cnidaria, with Ceriantharia	6.8-15.2	8.5-25.3	present study
	Echinodermata	6.0-12.2	N/A	Wada and Satoh 1994
Between subclasses	Anthozoa, without Ceriantharia	4.2-10.7	5.1-14.9	present study
	Anthozoa, with Ceriantharia	4.2-13.8	5.1-21.2	present study
Between orders	Hexacorallia	1.5-8.1	1.6-10.2	present study
	Pennatulacea/Alcyonacea	1.3-9.2	1.4-12.8	present study
	Helioporacea/Alcyonacea	0.3-8.2	0.3-11.6	present study
Between suborders	Hexacorallia	0.4-4.5	0.4-5.1	present study
	Pennatulacea, without *Umbellula*	1.6-5.1	1.6-5.8	present study
	Pennatulacea, with *Umbellula*	1.6-9.2	1.6-12.0	present study
	Decapoda	11.0-12.9	N/A	Kim and Abele 1990
Within families	Hexacorallia	0.4-2.6	0.6-2.9	present study
	Octocorallia	0.4-7.6	0.4-9.3	present study
	Mytilidae	2.7-4.5	N/A	Kenchington et al. 1995
Within genera	Hexacorallia	0.5-1.1	0.5-1.1	present study
	Octocorallia	0.6-1.6	0.6-1.7	present study
	Mytilus	0.1-0.6	N/A	Kenchington et al. 1995

N/A: Not available

The divergence between suborders within the Hexacorallia (0.4-4.5%) was similar to the divergence among suborders within the Pennatulacea (1.6-5.1%), exclusive of *Umbellula* sp. which did not branch with the other Pennatulacea. The inclusion of *Umbellula* raised the upper bound of divergence from 5.1% to 9.2% between suborders. This level of divergence was much lower than that found between suborders of decapod crustaceans (11-12.9%) (Kim & Abele 1990). The genetic divergence among the remaining suborders was more difficult to interpret for the Octocorallia, because the members of many suborders were mixed within each clade in my most likely trees (Fig. 3). Therefore I measured the divergence between and within the three major clades from our ML analyses. The divergence between the octocorallian clades ranged from 2.5-9.9%. Within clades, the divergence ranged from 0.4-8.4% in Clade A, 0.9-6.5% in Clade B, and 0.0-5.8% in Clade C. The divergence in Clade A was roughly equivalent to the ordinal-level divergence within the Hexacorallia, but the divergence within clades B and C was closer to the subordinal-level divergence within the hexacorals and Pennatulacea. The within-family divergence of the octocorals (0.4-7.6%) was much higher than that within the hexacorals (0.4-2.6%) as well as those found in Mytilidae (2.7-4.5%) (Kenchington et al. 1995).

Discussion

Phylogenetic analyses of nuclear 18S sequences from Octocorallia do not support either the historical or the current classification system. The phylogenetic clades evident within the Subclass Octocorallia did not correspond to the morphologically defined orders or suborders (Fig. 3). The clades present were similar, however, to the associations found by France et al. (1996) using partial mt 16S rDNA (Fig. 5A). Mitochondrial 16S sequence information also distinguished three groups, with a pennatulacean as the basal branch (corresponding to my Clade B), an undifferentiated clade containing species found in my

Fig. 5   Previous molecular phylogenetic studies examining
relationships within the Octocorallia. Numbers at nodes
represent bootstrap values.
A) From France et al. (1996), based on mitochondrial 16S
rDNA
B) From Song and Won (1997), based on nuclear 18S rDNA

A

- *Anthothela nuttingi*
- *Lophogorgia chilensis*
- *Protodendron* sp.
- *Alcyonium* sp.
- *Acanthogorgia* sp.
- *Lepidisis* spp.
- *Corallium* spp., *Paragorgia* sp.
- *Narella* spp.
- *Chrysogorgia chryseis*

96
99
100

Subclass Octocorallia

Order Pennatulacea

outgroups

B

100

Subclass Hexacorallia

Order Pennatulacea

76
98
100

- *Euplexaura crassa*
- *Bellonella rigida*
- *Calicogorgia granulosa*
- *Alcyonium gracillimum*

Subclass
Octocorallia

Subclass Ceriantipatharia: Ceriantharia

Hydrozoan outgroup

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Clade C, and a further unresolved clade of some of the same species found in my Clade A. A previous study using partial 18S rRNA sequences (Song & Won 1997) also found the one pennatulacean species branching first within the Octocorallia, but only had four other species representing the remaining octocorals (Fig. 5B). All four of those species corresponded to families within my Clade C.

The morphologically well-defined groups within the Octocorallia (Pennatulacea and Helioporacea) did not form monophyletic clades based on 18S sequence information. The pennatulacean species in this analysis formed a monophyletic group, with the exception of the genus *Umbellula* which fell in Clade A. Four non-pennatulacean species branched at the base of the pennatulacean clade. I could not verify the putative ancestral position of the Pennatulacea within the Octocorallia because the branching order of the three clades could not be established with these data. The helioporacean species *Heliopora* was found in Clade C and was not separate from the other octocorals, but this may be a result of using an incomplete sequence in the analyses. The 'restricted Holaxonia,' the final group of species considered by Bayer (1981) to be distinct, also failed to form a unified phylogenetic group. Members of those four families (Ifalukellidae, Chrysogorgiidae, Primnoidae, and Ellisellidae) could be found in all three clades.

Morphological taxonomy does not predict that the genus *Umbellula* would be more closely allied with *Anthomastus*, *Paragorgia*, and *Corallium* rather than the other Pennatulacea, given the characteristic morphology of the pennatulaceans. *Umbellula* is unique among the Pennatulacea, however, in that all of its autozooids form a cluster at the end of its rachis (Hickson 1930). Morphologically, *Umbellula* does have similarities to the alcyonacean species *Anthomastus* with which is it associated. *Anthomastus* is dimorphic, as are *Corallium* and *Paragorgia* (also within that subclade). *Anthomastus* possesses several large autozooids and many small siphonozooids, forming a distinct body at the top of a stalk devoid of polyps (Bayer 1993a). Both *Umbellula* and *Anthomastus*

have very large polyps. This resemblance is primarily superficial, however, and further investigation concerning morphological similarities between *Umbellula* and *Anthomastus* are necessary.

The unusual genus *Dendrobrachia* was clearly associated with the species of *Corallium* and *Paragorgia* included in these analyses. Opresko and Bayer (1991) concluded that *Dendrobrachia* was more closely related to the Family Chrysogorgiidae, based on its resemblance to the two chrysogorgiid species *Trichogorgia lyra* and *Malacogorgia (=Trichogorgia) capensis*. *Dendrobrachia* has a solid, chitinous axis devoid of calcium, and no free sclerites. *Malacogorgia capensis* has an identical, chitinous axis, and the axis of *Trichogorgia lyra* is similar but contains calcium deposits. Both *Trichogorgia lyra* and *Malacogorgia capensis* lack free sclerites, making them the only species of Scleraxonia or Holaxonia for which this is true (Opresko & Bayer 1991). The representative of the Family Chrysogorgiidae in this analysis (*Chrysogorgia chryseis*) branched within Clade A, as did *Dendrobrachia*, but *Dendrobrachia* could not be forced to branch with *Chrysogorgia* or its sister taxa without reducing the likelihood of the tree significantly (KH Test, P>0.05).

The morphological similarities of *Dendrobrachia* to *Corallium* and *Paragorgia* are not clear. Although the axis of *Corallium* is solid, as in *Dendrobrachia*, it is entirely calcareous (Bayer 1964). The axis of *Paragorgia* contains chitin as well as calcium, but its central core is hollow (Bayer 1993b). There are no clear morphological connections between *Dendrobrachia* and *Corallium*.

There is also morphological evidence for the association of the genera *Anthomastus* and *Paragorgia* as found from 18S data (Fig. 3). Broch and Horridge (1957) proposed uniting the two genera within the Family Paragorgiidae. Both genera are dimorphic, and they share similar forms of sclerites. Broch and Horridge asserted that *Anthomastus* differed from *Paragorgia* only in the lack of chitin in its central axis, a character they felt to

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be less important than the similarity in polyp and sclerite morphology. Bayer (1993a) dismissed the importance of sclerite similarity, however, noting that the particular form of sclerite the two genera share is fairly common among alcyonaceans.

The morphological similarities between *Corallium* and *Paragorgia* are numerous. *Paragorgia* was historically considered to be in the order Alcyonacea (now the Suborder Alcyoniina), but was later placed in the Suborder Scleraxonia (Bayer 1973). Their axial structures differ slightly. The axis of *Corallium* is solid and exclusively calcareous, whereas the axis of *Paragorgia* is chambered and contains both calcium and chitin. The growth form and sclerite structure of *Corallium* and *Paragorgia*, however, are virtually identical. *Corallium* and *Paragorgia* are the only genera within the Suborder Scleraxonia exhibiting colony dimorphism (Bayer 1964). The close phylogenetic association of the two genera is also indicated from mt16S rDNA analyses (Fig. 5) (France et al. 1996).

The importance of skeletal structures has been implicit in the creation of the current morphological taxonomy, specifically the subordinal divisions (historically ordinal divisions). The appearance of members of all suborders in most of the clades in my trees suggests that skeletal structure may not be the primary character indicative of evolutionary patterns.

One character that did correspond roughly to the observed branching pattern was the presence or absence of dimorphism in colony morphology. Dimorphism occurs in all species of the Pennatulacea, as well as several species in the Family Alcyoniidae (Suborder Alcyoniina), and the two families Coralliidae and Paragorgiidae (Suborder Scleraxonia). The members of the Suborder Holaxonia are exclusively monomorphic, as are the members of the Protoalcyonacea and the Stolonifera. The Order Helioporacea is also monomorphic (Bayer 1973). There were two small clades of dimorphic species from my data: Clade B contained the majority of the Pennatulacea, and half of Clade A contained the remaining pennatulacean and the other dimorphic species in this analysis (Fig. 3). The taxa at the

base of the pennatulacean clade (B) were monomorphic, but could be moved to clades A or C without reducing the likelihood of the tree significantly. All of the species included in our study from the Suborder Alcyoniina are monomorphic and fell in Clade C, with the exception of *Anthomastus* which is dimorphic and branched with the dimorphic species in Clade A. The correlation between the phylogenetic groupings I found within the Order Octocorallia and monomorphism vs. dimorphism is striking.

The morphological similarities among the dimorphic species are so few, however, that it would seem likely that dimorphism arose multiple times within the Octocorallia. Morphologically, it is difficult to imagine a single common ancestor for all of the dimorphic species. The monophyly of dimorphism can be forced topologically, however (Fig. 4), without resulting in a significantly lower likelihood for the overall tree (KH Test, $P<0.05$). Dimorphism may be a functional constraint, however, based on colony structure rather than common ancestry. The branched, lobate, and massive octocorals are all dimorphic, which suggests that dimorphism arose in response to the need for transporting water more efficiently through a large structure (Bayer 1973). My analyses cannot reject either the monophyly or the polyphyly of the dimorphic character.

The one clear exception to the pattern of dimorphism found in our trees was the genus *Dendrobrachia*, which is entirely monomorphic, yet clustered tightly with the dimorphic genera *Corallium* and *Paragorgia*. The simplest way to explain the association is to assume the dimorphism trait was lost during *Dendrobrachia*'s evolution, although more evidence is needed to support such a conjecture.

The morphological characters used to derive the current classification system do not appear to be reflected in the genetic associations I have found. The relative importance of several of these characters to the evolutionary history of the octocorals needs to be re-examined. The nuclear 18S rDNA gene, however, may not be appropriate for these particular analyses. Although the 18S gene has been used to elucidate phylogenetic

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relationships at the taxonomic levels of order and suborder in previous studies of other invertebrate taxa, the level of divergence 18S rDNA exhibited in the present study did not allow me to distinguish definitive phylogenetic relationships within the Subclass Octocorallia. Analyses of 18S rDNA sequences could not distinguish relationships within a large subset of species within this subclass, those species branching in Clade C of our analyses (Fig. 3). The high level of divergence found within families may reflect incorrect familial designations within the octocorals. Indeed, Bayer (Bayer 1956) comments that several genera are incorrectly included in existing families, and that these relationships need to be reassessed in many cases. There were distinct phylogenetic groups indicated by 18S sequence information, corresponding to the three clades we found, but relationships within those clades remains equivocal. Sequences from a different gene, exhibiting higher levels of divergence, may be necessary to delineate relationships beyond those found in this study.

Conclusions

This study has shown that the traditional, morphological taxonomy of the Subclass Octocorallia is not reflected in phylogenetic structure as indicated from 18S rRNA sequence information. Three phylogenetically distinct clades were evident, but they do not correspond to current subordinal divisions. Nuclear 18S rDNA sequence information did indicate some genetic structure within the Octocorallia, particularly in Clade A (Fig. 3). The largest clade (Clade C) contained nearly half of the species used in these analyses, but the phylogenetic signal was so low that the relationships within this clade could not be determined from these sequence data. A similar clade was also present in an earlier analysis using mt16S rDNA (France et al. 1996), which may indicate this is a ribosomal-specific pattern. More likely, however, the branching similarity resulting from the two independent data sets suggests that low levels of divergence are truly reflective of the

evolutionary history of these species. These low levels of divergence are suggestive of a rapid radiation in the evolutionary history of these taxa. The morphological continuum present within the Octocorallia and the lack of an extensive fossil record, however, make it very difficult to substantiate such an hypothesis using these characters.

The two morphologically well-established orders, the Pennatulaca and the Helioporacea, did not constitute entirely distinct genetic entities in these analyses. The majority of the pennatulaceans in this study were grouped together in a monophyletic clade, but the genus *Umbellula* was phylogenetically distinct from the other members of its order. The level of divergence between *Heliopora* and the remaining Octocorallia was similar to the divergence between the Pennatulacea and the Alcyonacea, but *Heliopora* clustered tightly within the undifferentiated Clade C (Table 3). This close association suggests that the Helioporacea are not highly differentiated from the Alcyonacea, although additional specimens and complete sequences from the Helioporacea may be necessary to confirm this hypothesis. Additional specimens from the Pennatulacea and *Umbellula* would be essential for confirming or refuting the genetic divergence of *Umbellula* from the otherwise monophyletic Pennatulacea.

The morphological characters of axial composition, sclerite form and arrangement, and general colony configuration are the primary characters that have been used to create the ordinal and subordinal groupings within the Subclass Octocorallia. There was very little correlation between those characters and the phylogenetic groups indicated with 18S sequence information. The character of monomorphism vs. dimorphism appeared relatively consistent in the trees I have produced, as all of the dimorphic species in this analysis clustered in two clades. The placement of the monomorphic genus *Dendrobrachia* was the one exception to the unity of the dimorphism character. *Dendrobrachia* branched very closely to the genera *Paragorgia* and *Corallium*, both of which are dimorphic. The axial morphology of *Dendrobrachia* and its lack of sclerites suggest a closer affinity with

the family Chrysogorgiidae, which was not supported from these analyses. Further morphological study and sequence information from additional genes will be necessary to clarify the phylogenetic relationship of *Dendrobrachia* to the other octocorals.

This study constitutes a broad-scale survey of genetic differentiation of nuclear 18S rDNA sequences across the entire subclass, representing the majority of the morphological diversity present in the subclass. The morphological characters that have been used to devise the traditional taxonomy of the octocorals do not correspond to the phylogenetic divisions reflected in genetic sequence information. The phylogenetic structure that was present indicated a well-supported clade primarily containing the dimorphic Scleraxonia, and a large undifferentiated clade containing half of the species from these analyses. The majority of the pennatulaceans formed a monophyletic group, with the exception of *Umbellula*. The remaining species fell into weakly-supported clades that could be moved without reducing the likelihood of the tree significantly. This branching pattern was upheld by analyses of mt 16S rDNA, which constitutes a second independent molecular character. The importance of the morphological characters used to create the traditional taxonomies may need to be reassessed as they relate to the evolution of these species. Additional characters will be required, either morphological characters or sequences from additional genomic regions, to further clarify the evolutionary progression of the Subclass Octocorallia.

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Chapter 5

Conclusions

Summary

The goal of this thesis project was to build a more complete molecular phylogeny of the Class Anthozoa than currently exists, based on the nuclear 18S rRNA gene. I addressed four primary questions concerning the phylogenetic divisions within the Anthozoa. In Chapter 3, I examined the subclass divisions within the Anthozoa, specifically to address the evolutionary relevance of the Subclass Ceriantipatharia. The orders Ceriantharia and Antipatharia were originally classified in the Subclass Hexacorallia, but were subsequently assigned to their own subclass. Previous molecular studies had suggested that the orders Ceriantharia and Antipatharia are genetically disparate, but the taxonomic sampling in those studies was insufficient to determine the precise affinities of the two orders relative to the remaining Anthozoa.

My analyses showed the orders within the Subclass Ceriantipatharia (Antipatharia and Ceriantharia) to be genetically dissimilar. Therefore, this subclass does not represent an evolutionarily relevant grouping. The Antipatharia were most closely related to the Zoanthidea (Subclass Hexacorallia), and the Ceriantharia appeared to be ancestral to the Hexacorallia. The exact phylogenetic position of the Ceriantharia, however, could not be determined with these sequence data.

I also examined the ordinal divisions within the Hexacorallia and the Ceriantipatharia in Chapter 3, to determine if the morphologically derived divisions are monophyletic or polyphyletic. The Order Scleractinia was monophyletic based on previous studies of both nuclear 18S rDNA and 28S rDNA, but polyphyletic based on mitochondrial 16S rDNA. The Order Actiniaria appeared to be monophyletic based on mt 16S rDNA, but was polyphyletic from the 18S and 28S studies. The 28S rDNA sequence information suggested the Order Corallimorpharia is also polyphyletic.

The Subclass Octocorallia and the hexacorallian orders Antipatharia, Zoanthidea and Actiniaria were each monophyletic based on my 18S sequence analyses. The Scleractinia and Corallimorpharia appeared to be polyphyletic and were closely associated with each other, but their exact relationship could not be determined reliably with these data. These data also could not be used to distinguish the branching hierarchy for the orders within the Hexacorallia.

Chapter 4 addressed the phylogenetic divisions within the Subclass Octocorallia. Traditional taxonomy was based on very few morphological characters, and the evolutionary significance of any given character is unclear. The traditional taxonomic system divided the subclass into seven orders. Recent taxonomic revisions retained two of the orders (Helioporacea and Pennatulacea) but combined the remaining species into a single order (Alcyonacea) with five subordinal divisions. Mitochondrial 16S rDNA suggested that neither the historical ordinal-level nor the current subordinal-level divisions correspond with the genetic structure of the subclass. I included a more thorough taxonomic sampling in the present study, in order to produce a more complete picture of the phylogenetic structure present within the subclass.

Several specimens for this chapter were alcohol-preserved, acquired from museum collections. I have described the molecular methods I used for determining sequences from these specimens in Chapter 2. Much of the DNA from these specimens was degraded, and standard PCR amplifications were usually unsuccessful. Using an extended DNA extraction protocol combined with PCR reamplifications using taxon-specific primers, sequences of length 700-1800 bp were determined from specimens that had been preserved up to fifty years.

My phylogenetic analyses indicated that the morphologically distinct groups within the Subclass Octocorallia do not constitute phylogenetically distinct entities. Three phylogenetic clades were present within the subclass, none of which corresponded to the

traditional morphologically based divisions. The Pennatulacea were primarily monophyletic, but the pennatulacean genus *Umbellula* branched with the dimorphic alcyonaceans. The Helioporacea did not appear to be phylogenetically dissimilar from species of the Order Alcyonacea. The morphological character of colonial dimorphism was loosely correlated with phylogenetic structure, but this association was not well-supported. Nearly half of the species in this study, including representatives from all five suborders of the Alcyonacea, clustered together in a large, undifferentiated clade. The low levels of genetic divergence within this clade suggest a rapid radiation of species occurred at some point in the evolutionary history of the Anthozoa.

Chapters 3 and 4 include an examination of the phylogenetic affinities of two species with enigmatic morphologies, *Dactylanthus antarcticus* (representing the Order Ptychodactiaria) and *Dendrobrachia paucispina*. The Ptychodactiaria were originally classified as members of the Order Actiniaria (the anemones), although their musculature, nematocysts and mesenterial structure differ from the Actiniaria. In 1949, separate ordinal distinction for the Ptychodactiaria was established with the argument that the Ptychodactiaria represent a separate evolutionary line. In my sequence analyses, *Dactylanthus* branched within the Actiniaria, most closely with the Tribe Athenaria. The close association of *Dactylanthus* with the Athenaria suggested that the ordinal-level distinction of the Ptychodactiaria was phylogenetically unwarranted .

Dendrobrachia paucispina was originally classified with the Order Antipatharia (the black corals) based on its axial morphology, but was recognized at the time as anomalous compared to the other antipatharians. Subsequent examinations of the polyp morphology suggested *Dendrobrachia* was more closely related to the chrysogorgiid octocorals (Alcyonacea: Holaxonia). Based on my 18S sequence analyses, *Dendrobrachia* was closely affiliated with the Octocorallia. The affinity of *Dendrobrachia* with the Octocorallia rather than the Antipatharia suggests that polyp morphology, not axial morphology, is more

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indicative of the evolutionary ancestry of this group. *Dendrobrachia* fell within the clade containing the Family Chrysogorgiidae, but was actually more closely related to species of *Corallium* and *Paragorgia*. Morphological characters that support this association are unclear.

This thesis project represents the most comprehensive molecular phylogenetic analysis of the Class Anthozoa to date. Complete sequences from the nuclear 18S rRNA gene were determined from 58 species, representing all extant orders of the subclasses Hexacorallia, Octocorallia and Ceriantipatharia, and 22 of the 30 families within the Alcyonacea (Subclass Octocorallia). Sequences from 19 species in GenBank were also included in the analyses. Previous molecular studies have addressed phylogenetic relationships within the Class Anthozoa, but they all used limited taxonomic sampling and relatively simple methods of analyses. The more thorough taxonomic sampling of this project helped further clarify a number of the relationships examined in other studies. The use of maximum likelihood techniques and realistic evolutionary models for the analyses of these sequence data yielded results that could be compared statistically to alternate hypotheses suggested in other studies.

This characterization of phylogenetic relationships gives us a greater understanding of the evolutionary progression within the Class Anthozoa. The simple morphologies of the species in this group make it difficult to establish taxonomic divisions based solely on morphological characters. As a result, the traditional taxonomy of this group often depicted 'categories' of species based on similar convergent morphologies rather than evolutionarily relevant associations. This project helped illuminate the morphological characters that may have greater significance in retracing the evolution of the Anthozoa. Anthozoans are significant members of nearly all marine environments, and a better understanding of their evolutionary associations and their diversity will help us better manage these important biological resources.

Future Directions

This thesis project included complete 18S rDNA sequences from a very thorough representation of the species within the Class Anthozoa, and used relevant evolutionary models to analyze them. Although these analyses could clearly demonstrate some aspects of the phylogenetic associations within the Anthozoa, a number of relationships could not be determined from these sequence data. The nuclear 18S gene had sufficient phylogenetic signal to establish the primary divisions within the class, but could not resolve many of the associations among those divisions. Although the Ceriantharia were clearly divergent from the remaining Anthozoa based on these 18S sequences, their precise phylogenetic position remains equivocal. Similarly, the relationship between the orders Corallimorpharia and Scleractinia could not be clearly established with 18S information. Sequence information from additional taxa and different genomic regions will be necessary to further clarify these relationships.

There is grandeur in this view of life, with its several powers,
having been originally breathed into a few forms or into one;
and that, whilst this planet has gone cycling on
according to the fixed law of gravity, from so simple a beginning
endless forms most beautiful and most wonderful
have been, and are being, evolved.

--Charles Darwin
The Origin of Species

Appendix 1

Appendix 1 Full alignment of 18S rDNA sequences for Chapter 3, shown in NEXUS format for PAUP*. Positions removed for analyses:
1-48, 63, 107-113, 136, 171-184, 214-233, 242-264, 299-308, 318, 400, 528-529, 533, 537, 566, 572, 718-724, 782-785, 789, 835-837, 913, 948-949, 1314, 1443-1455, 1483-1484, 1578-1581, 1774-1816, 1829-1887.

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[Name: Lepidisis          Len: 1887   Check: 492A4A84]
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[Name: BellonellaGEN      Len: 1887   Check: A0BBC1C6]
[Name: Protoptilum        Len: 1887   Check: 68561E5]
[Name: N_bowersi          Len: 1887   Check: 4ED0D0E8]
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format datatype=dna interleave missing=-;
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Anemonel   CATATGCTTGTNTCAAAGAT  TAAGCCAATGCAATGTCTAAGT  ATAAGCA-CT-TGTACTGTG  AAACTGCGAATGGGCTCATTA  AATCAGTTATCGTTTATNTG
Lepidisis  CATATGCTTGTCTCCAAGT   TAAGCCAATGCACGTCCAAGT   ACGAGCA-CT-TGTACTGTG  AAACTGCGAATGGGCTCATTA  AATCAGTTATCGTTTATTTG
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Stichopat  CATATGCTTGTCTCAAAGAT  TAAGCCAATGCAATGTCTAAGT  ATAAGCA-CT-TGTACTGTG  AAACTGCGAATGGGCTCATTA  AATCAGTTATCGTTTATTTG
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Pavona     CATATGCTTGTCTCAAAGAT  TAAGCCAATGCAATGTCTAAGT  ATAAGCA-CT-AGTACTGTG  AAACTGCGAATGGGCTCATTA  AATCAGTTATCGTTTATTTG
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Discosoma  CATATGCTTGTCTCAAAGAT  TAAGCCAATGCANTGTCTAAGT  ATAAGCACCT-AGTACTGTG  AAACTGCGAATGGGCTCAATTA AATCAGCTATCGTTTATTTG
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Dendro2    CATATGCTTGTCTCAAAGAT  TAAGCCAATGCAATGTCTAAGT  AGGAGACACT-TGTACTGTG  AAACTGCGAATTGCTCATTA   AATCAGTTATCATTTATTTG
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Anemonel   ATTGTPACC--T--TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Lepidisis  ATTGTPACCA----TTGCTAC  ATGGATAACTGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
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Phyllangi  ATTGTPACC-----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Cerianthu  ATTGTPACCC----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- -AGTG-AAGGGACGTATTTTA  -AGTG-AAGGGACGTATTTTA
Parazoant  ATTGTPACCA----TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Enallopsa  ATTGTPACCA----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Cerianthe  ATTGTPACCC----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- -AAGTCCCGGACACCTTAA-  -CGGTGGAGGGATGTATTTA
Zoanthid1  ATTGTPACCA----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACTT------   -CTTGGAAGGGATGTATTTA
Corynacti  ATTGTPACCA----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACTT------   -TCTGGAAGGGATGTATTTA
Dactylant  ATTGTPACG-----TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Haloclava  ATTGTPACG-----TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCGGGAGGGATGTATTTA
Acanthopt  ATTGTPACCTCTTACTACTAC  TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Metridium  ATTGTPACC--T--TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Fungia     ATTGTPACC-----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Bathypath  ATTGTPACCA----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Taiaroa    ATTGTPACTCT---CTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACTCT------  -CGTGGAAGGGATGTATTTA
Tubipora   ATCGTPACCC----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACTTCTT----  -CTCGGAAGGGACGAGTTTG
Pavona     ATTGTPACCA----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Stomphia   ATTGTPACAACT--TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AGAGTCCCGGACTCGCGTTCG  CGCAGGAAGGGATGTATTTA
Discosoma  ATTGTPACAA----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AGAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Palythoa   ATCGTPACGGCCATAGAATTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAATCCCGGACTTCTT----  -TCTGGAAGGGACAGTTTTG
Antipathe  ATTGTPACCA----TTTACTAC TTGGATAATCCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Cirripath  ATTGTPACCT----TTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
AntipatGE  ATTGTPACCA----TTTACTAC TTGGATAACCGTAGTTAATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Epiactisg  ATTGTPACGC----TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACTTTTA----  -TC-GGAAGGGATGTATTTA
Flosmaris  ATTGTPACAA----TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TC-GGAAGGGATGTATTTA
Rhizopsam  ATTGTPACCT----TTTACTAC TTGGATAACCGTAGTT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Tubastrae  ATTGTPACCA----TTTACTAC TTGGATAACCGTAGTT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTATTTA
Umbellula  ATTGTPACC-----TTTACTAC ATGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -ACTGGAAGGGATGTCATTGA
Renilla    ATTGTPACCTC---TTTACTAC TTGGATAACCGTAGC-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  -TCTGGAAGGGATGTCATTTG
Dendro2    ATTGTPACCT----TTTGCTAC TTGGATAACCGTAGC-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT-----TC   TAACGGAAGGGATGTATTTA
Briareum   ATTGTPACCTT---CTTACTAC TTGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACTT-------  -TCTGGAAGGGATGTATTTA
Mnemiopsi  ATTGTPGCCC----TTTACTAC ATGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACT--------  TACAGGAAGGGATGTATTTA
Selaginop  ATTGTPACAC----TTCTTAC  ATGGATATCTGTGGT-AATT CTAGAGCTAATACATGCGA- AATCTCCCAAACTT------   TACAGGAAGGGATGTATTTA
Beroe      ATTGTPGCCC----TTTACTAC ATGGATAACCGTAGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACTT------   -TC-GGAAGGGATGTATTTA
Scypha     ATGGTPGAC-----TTTACTAC TTGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGTT AAAGTCCCTGAC--------G  CGC-GGGAAGGGACGTATTTA
Tetilla    ATGGTCGTT-----TTTGCTAC ATGGATAATACTGTGGT-AATT CTAGAGCTAATACATGCAC- AAGGTCCCC-ACT-------  TTT-GGGAGGGGACGTATTTA
Tripedali  ATCGTA--------TCCTTAC  ATGGATAACTGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGGACC-------  -TCTGGAAGGGATGTATTTA
Trichopla  ATCGTPACA-----TTPACTAC ATGGATAACCGTGGT-AATT CTAGAGCTAATACATGCGA- AAAGTCCCGAC------TT   -TGGCGGAAGGGGATGTATTTA
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Anemoniag  TTAGATTCAAAAACCAATGCG GGTT-------C-TGCCCGG TGCT-----------------  --TTGGTGATTCATAATAGTAAC TGATCGAAATCGGCATGGGCCTT
Anthopleu  TTAGATTCAAAACCAATGCG  GGTT-----C-CGCCCGG  TGTG-----------------  --TTGGTGATTCATAATAGTAAC TGTTCGAAATCGCACGGGCCTT
Anemonel   TTAGATTCAAAACCAATGCG  GGTT-----C-TGCCCGG  TTCT-----------------  --TTGGTGATTCATAATAGTAAC TGTTCGAAATCGCACGGGCCTT
Lepidisis  TTAGATTCAAAACCAATGCG  GGTT-----CACGCCCGG  T-ACC----------------  --TTGGTGATTCACAATGAC    TCTGGGAAATCGCATGGGCCTT
Acanthogo  TTAGATTCAAAACCAATGCG  GCTT-----AACGGCCGC  TTTACC---------------  ACTTGGTGATTCATAGTAAC    TGTTCGAAATCGCATGGGCCTT
Bellonell  TTAGATTAAAAACCAATGCG  GCTT-----AACGGCCGC  TTAAC---------------C  ACTTGGTGATTCATAGTAAC    TGTTCGAAATCGCATGGGCCTT
Protoptil  TTAGGTTAAAAAGCCAATGCG GGTT-----CACGCCCGG  TT-------------------  CCTTGGGTGATTCATAATAAC   TATTCGAAATCGCATGGGCCTT
N_bowersi  TTAGATTCAAAACCGATGCG  GGTT-----CGGCCCGG   T--------------------C ATTTGGGTGATTCATAGTAAC   TGATCGAAATCGCATGGGCCTT
Stichopat  TTAGATTAAAAACCAATGCG  GGTT-----CTGCCCGG   TG-------------------  CTTTGGGTGATTCATAATAAC   TTTTGGATCGCATGGGCCTT-
Hormathi   TTAGATTCAAAACCAATGCG  GGTT-----CTGCCCGG   TTT------------------  CTTTGGGTGATTCATAATAAC   TGAACGAAATCGCACGGGCCTT-
Ceratotro  TTAGATTAAAAACCAATGCG  GGTGGGTTTCTGACTGCCCGG TGT-------------------  CTTTGGGTGATTCATAGTAAC   TTTTGGATCGCATGGGCCTT
Phyllangi  TTAGATTAAAAACCAATGCG  GGTT-----CTGCCCGG   TT-------------------  ATTGGGTGATTCATAATAGTAAC TGTTCGAAATCGCACGGGCCTTA
Cerianthu  TTAGATTAAAAAGCCAATGCA ACTGTTGATT---------CGG TTGTGG---------------  TTGTGGGTGATTCATAGTAAC   TGATCGAAATCGCATGGGCCTT
Parazoant  TTAGATTAAAAAACCAATCCG GTTT-------CCGGCCGG TA-------------------  --TTGGTGATTCATAGTAAC    TGATCGAAATCGCACGGGCCTT
Enallopsa  TTAGATTAAAAACCAATGCG  GGTT-----CTGCCCGG   TTCT-----------------  --TTGGTGATTCATAGTAAC    TGATCGAAATCGCACGGGCCTT
Cerianthe  TTAGATTAAAAAACCAATACG GT-------GGGCCGG    CTTCGGTCGGCACGCCGGGAT  CGTTGGGTGATTCATAGTAAC   TGAGGGAATCGCATGGGCCTT-A
Zoanthid1  TTAGATTAAAAAACCAATGCG GTTT-----CGGGCCGGC  ATT------------------  --GTGGTGATTCATAGTAAC    TTGTCGAAATCGCATGGCCT-
Corynacti  TTAGATTAAAAAACCAATGCG GTTT-----CTGCCCGG   TTGT-----------------  --TTGGTGATTCATAGTAAC    TTCACGAAATCGCACGGGCCT-
Dactylant  TTAGATTCAAAAACCGATGCG GGTT-----CTGCCCGG   TCCT-----------------  --TTGGTGATTCATAGTAAC    TTATCGAAATCGCATGGGCCT-
Haloclava  TTAGATTCAAAACCAATGCG  GGTT-----CCGCCCGG   TACT-----------------  --CTGGTGATTCATAGTAAC    TCGATCGGATCGCAGGGCC-
Acanthopt  TTAGATTAAAAAGCCAAACCG TGCG-----CAACGCGG   CCTT-----------------  --CTGGTGATTCATAGTAAC    TTTTGGAATCGCATGGGCCT-
Metridium  TTAGATTCAAAAACCAATGCG GGTT-----CTGCCCGG   TTCT-----------------  --TTGGTGATTCATAATAAC    TGATCGAAATCGCACGGGCCT-
Fungia     TTAGATTAAAAAACCAATGCG GGTT-----CTGCCCGG   TTCT-----------------  --TTGGTGATTCATAGTAAC    TGATCGAAATCGCATGGGCCT-
Bathypath  TTAGATTAAAAAAACCAATGCG GCTT-----CTGCCCGG   TGCT-----------------  --TTGGTGATTCATAATAAC    TGATCGAAATCGCATGGGCCTT
Talaroa    TTAGATTAAAAACCAATGCG  GCTT-----CGGGGCCGG  TTACCCAC-------------  --TTGGTGATTCATAATAAC    TGTTCGAAATCGCACGGGCCTT
Tubipora   TTAGATTAAAAAACCAATGCG GCTT-----CGGCGGCCGC TCAACCAC-------------  --TTGGTGATTCATAGTAAC    TGTTCGAAATCGCATGGGCCTT
Pavona     TTAGATTAAAAAACCAATGCG GTTT-----CTGCCCGG   TCAT-----------------  --TTGGTGATTCATAGTAAC    TGATCGAAATCGCACGGGCCT-
Stomphia   TTAGATTCAAAACCGATGCG  GGGCCTC--GTGCCCGG   TGAC-----------------  --TTGGTGATTCACAATAAC    TGCTCGAAATCGCAGGGCCT-
Discosoma  TTAGATGAAAAAACCAATGCG GGT---GGGCAACGCGCCCGG TGGTA----------------  --TGGGTGACTCATAGTAAC    TGATCGAAATCGCAGGGCCT-
Palythoa   TTAGAGTAAAAACCGATCCG  GTTT-----CGGCCGG    TCTCG----------------  --AGGTGACCCATAGTAAC     TGATCGAAATCGCATGGGCCT-
Antipathe  TTAGATTAAAAAACCGATGCG GGTT-----CTGCCCGG   TGCT-----------------  --TTGGTGATTCATAATAAC    TGATCGAAATCGCATGGGCGT-
Cirripath  TTAGATTAAAAAACCAATGCG GGTT-----CTGCCCGG   TGCT-----------------  --TTGGTGATTCATAATAAC    TGATCGAAATCGCATGGGCCT-
AntipatGE  TTAGATTAAAAACCAATGCG  GGTT-----CTGCCCGG   TGCT-----------------  --TTGGTGATCCATAATAAC    TGATCGAAATCGCATGGGCCTT
EpiactisG  TTAGATTCAAAACCAATGCG  GGTT-----CTGCCCGG   TTCT-----------------  --TTGGTGATTCATAGTAAC    TGATCGAAATCGCATGGGCCT-
Plosmaris  TTACATTCAAAACCAATGCG  GGTT-----CTGCCCGG   TGCT-----------------  --TTGGTGATTCATAGTAAC    TGTTCGAAATCGCACGGGCCT-
Rhizopsam  TTAGATTAAAAAACCAATGCG GGTT-----CTGCCCGG   TTCT-----------------  --TTGGTGATTCATAGTAAC    TGATCGAAATCGCACGGGCCT-
Tubastrae  CTAGATTAAAAAAACCAATGCG GGTT-----CTGCCCGG  TTCT-----------------  --TTGGTGATTCATAGTAAC    TGATCGAAATCGCACGGGCCT-
Umbellula  TTAGTATTAAAAACCAGAGTCG GGTT------CGTAAGTCCGG TTCT-----------------  --TTGGTGATTCTGAAGTAAC   TGTGCCAATCGCATGGGCCT-
Renilla    TTAGATTAAAATACCAATGCG GA---CGTAAGTCCGG    TTCT-----------------  --TTGGTGATTCTAAATAAC    TCTTCGAAATCGCATGGGCCT-
Dendro2    TTAGATTAAAACCGATGCG   GGTGTACGC--CTGCTTTG CGTG-----------------  --TTGGTGATTCATGGGCCTT   TGTGGGAAATCGCATGGGCCTT
Briareum   TTAGATTAAAAACCAATGCG  GGTT-----AACGCCCGG  TGTG-----------------  --TTGGTGATTCTAAATAAC    TTATCGAAATCGCATGGGCCTC
Mnemiopsi  TTAGAGTAAAAAACCAATGCG GTCT-------TCGGGGCT T--------------------  --TTCGGGTGATTCATAATAAC  TGTTNGAAATCGGTACGGGCCTT
Selaginop  TTAGATTAAAAACCAATGCG  -TTT-----TCGGGGGCT  CGCA----------------T  TAAAGATGACTCATGATAAC    TTTTGGAAATCGTACGGGCCTT-
Beroe      TTAGAGTTAAAAACCGATGCG GGTT-----AACGACGCT  T--------------------  --TCGGGTGATTCATGATAAC   TGTTNGAAATCGTAGGGCCTT
Scypha     TTAGATCCAAAACCGATGCA  GTCGA-------AAGGCTGG TT-------------------  --TCGGTGATTCATGATAAC    TGAACGGATGCGCATGGTCTT
Tetilla    TTAGATCCAAAACCAGCCGG  GCTC----CTCGTGGTCCCGG TCC------------------  --CTGGGCGGATTCATAGTAAC  TGTTCGAAATCGCACGGGCCTT
Tripedali  TTAGACTAAAAGGCCAATACC GGTT-------CGGCACCGG  TTCTA----------------  --TTGGTGATTCATGATGATAAC TTCTCGAAATCGCACGGGCCTT
Trichopla  TTAGATCAAAAACCAATGCG  GGCT-----TGCCCGG    TGT------------------  --TTGGTGATTCATAATAAC    TTATCGAAATCGCATGGGCCTT
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AnemoniaG   -------------GCGGCTGGCG-AT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTGTTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Anthopleu   G------------GCGGCTGGCGGAT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTATTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Anemonel    -------------GAGCTGGCG-AT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Lepidisis   -------------TGCGCGGCG-AT  GTTNCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGANNAT-
Acanthogo   CTCTCGTTCGTGCGCGGCG-AT     GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Bellonell   CTCTCGTTCGTGCGCGGCG-AT     GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Protoptil   A------------TGCGCGGCG-AT  GATGCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
N_bowersi   -------------TGCGCGGCG-AT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Stichopat   -------------CGAGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Hormathii   -------------TGCGCGGCG-AT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Ceratotro   -------------CGCGCGGCG-AT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Phyllangi   -------------GCGCGGGCG-AT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Cerianthu   TCG----------TGCGCGGCG-AT  GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Parazoant   -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Enallopsa   -------------TGCGCGGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Cerianthe   TCT----------TGCGCGGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTG  ACAACGGGGTGACGGAGAAT-
Zoanthid1   -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Corynacti   -------------CGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Dactylant   -------------TGCGCCAGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Haloclava   -------------TCGCGCGGCG-AC GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Acanthopt   -------------TGGTACCGGCG-AT GTTTCATTCAAAATTTCTGCC CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Metridium   -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Fungia      -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Bathypath   -------------CGAGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  ATAACGGGGTGACGGAGAAT-  GCAACGGGGTGACGGAGAAT-
Taiaroa     CTTTGTTCGTGCGCGGCG-AT      GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Tubipora    CA--CTTTGCGCGGCG-AT        GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTC  GCAACGGGGTGACGGAGAAT-
Pavona      -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  GCAACGGGGTGACGGAGAAT-
Stomphia    -------------GGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Discosoma   -------------TGAGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGCAGCGGCTTACCATGGGCT  ACAACGGGGTGACGGAGAAT-
Palythoa    -------------CGAGCTGGCG-AT GTCACATTCAAAATTTCTGCC  CTATCAGCTCTTTCGAATGGTAA GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Antipathe   -------------CGAGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Cirripath   -------------TGAGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
AntipatGE   -------------CGAGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
EpiactisC   -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Flosmaris   -------------CGAGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Rhizopsam   -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Tubastrae   -------------TGCGCTGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  GCAACGGGGTGACGGAGAAT-
Umbellula   -------------CGAGCGCGGCG-AT GTTTCATTCAAAATTTCTGCC CTATCAAACTGTCGAATGGTAA  GGCAGCGGCTTACCATGGGTT  GTAACGGGGTGACGGAGAAT-
Renilla     -----------CACGTGCCGGCG-AT GTTTCATTCAAAATTTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  ACAACGGGGTGACGGAGAAT-
Dendro2     -------------TGCGCGCGGCG-AT GTTTCATTCAAAATTTCTGCC CTATCAAACTGTCGAATGGTAA  GGTAGTGGCTTACCATGGGTT  GCAACGGGGTGACGGAGAAT-
Briareum    -------------TCGTGCGCGGCG-AT GTTTCATTCAAAATTTCTGCC CTATCAAACTGTCGAATGGTAA GGTAGTGGCTTACCATGGGTG  GCAACGGGGTGACGGAGAATG
Mnemiops    -------------CGTGCGCGGCG-AT GTTTCATTCGAGTTTCTGCC   CTATCAAACTTTCGAATGGTAA  GGTAGTGGCCTACCATGGGTT  ACAACCGGGTGACGGAGAAT-
Selaginop   -------------CGGTGCGGACG-AT ATTTCTTTCAAAATTATCTGCC CTATCAAACTTTCGAATGGTAA GGTAATTGGCTTACCATGGGTG GCAACGGGGTGACGGAGAAT-
Beroe       A------------GTGCGGCG-AT   GACTCATACAAAAATATCTGCC CTATCAAACTTTCGAATGGTAA  GGTAGTGGCCCTACCATGGGTT TTTACGGGTGACGGAGAAT-
Scypha      G------------GCGGCCGGCG-AT GGTCCATTCAAAAATTCTGCC  CTATCAAACTTTCGAATGGTAC  GGTAGTGGCCTACCATGGGTT  GCAACGGGGTAGCGGAGAAT-
Tetilla     G------------GCGCCGGCG-AT  GTTTCATTCAAAAATTCTGCC  CTATCAAACTGTCGAATGGTAA  GGTAGTGGCCTACCATGGGTT  GCAACGGGGTAGCGGAGAAT-
Tripedali   -------------GTACCGGCG-AT  GTTTCATTCAAAATATCTGCC  CTATCAAACTTTCGAATGGTAC  GGTAGTGGGCTTACCATGGGTT GCAACGGGGTAACGGAGAAT-
Trichopla   -------------GTGCCGGGCG-AT GCTTCATTCAAGTTTCTGCC   CTATCAAACTTTCGAATGGGTAA GGTATTGGGCTTACCATGGGTT ACAACGGGGTAACGGAGAAT-
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Anemoniac   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Anthopleu   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Anemonel    TAGGGTTCGATTCCGGAGAG GCAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTNACCCAATC CTGACTCAGGGAGGTAGTGA
Lepidisis   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Acanthogo   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Bellonell   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Protoptil   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTGGGGAGGTAGTGA
N_bowersi   CAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CCGACCGCAGGGAGGTAGTGA
Stichopat   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Hormathii   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Ceratotro   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGATTCAGGGAGGTAGTGA
Phyllangi   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Cerianthu   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Parazoant   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACACAGGGAGGTAGTGA
Enallopsa   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACCCAGGGAGGTAGTGA
Cerianthe   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGATTCAGGGAGGTAGTGA
Zoanthidl   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Corynacti   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACACAGGGAGGTAGTGA
Dactylant   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGATTCAGGGAGGTAGTGA
Haloclava   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Acanthopt   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Metridium   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Fungia      TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATCACCCAATC CTGACTCAGGGAGGTAGTGA
Bathypath   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Taiaroa     TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGAGGTGGGGAGGTAGTGA
Tubipora    TAGGGTTCGATTCCGGAGAG GGAGTCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Pavona      TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAATCGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Stomphia    TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Discosoma   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Palythoa    TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACACAGGGAGGTAGTGA
Antipathe   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Cirripath   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
AntipatGE   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Eplactisc   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Flosmaris   TAGGGTTCGATTCCGGAGAG GGAGCCTTAGAGACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTCAGGGAGGTAGTGA
Rhizopsam   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACTTAGGGAGGTAGTGA
Tubastrae   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CTTATCCAAGGAGGCAGCA GGCGCGCAAATTACCTAATC CTGACTCAGGGAGGTAGTGA
Umbellula   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGGGCGTAAATTACCCAATC CCGACACGGGGAGGTAGTGA
Renilla     TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CCGACACGGGGAGGTAGTGA
Dendro2     CAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGGGCGTAAATTACCCAATC CTGACACGGGGAGGTAGTGA
Briareum    TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CCGACGGGGGGAGGTAGTGA
Mnemiopsi   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CCGATTCGGGGAGGTAGTGA
Selaginop   CAGGGTTCGGTTCCGGAGAG GGACGCGAGAAACGGCTAC CACATCTAAGGAGGCCGCA GGCACGGCAAATTACCCAATC CCGAATTCGGGGAGGTAGTGA
Beroe       TAGGGTTCGATTCCGGAGAG GGAGCCCGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CCGATTCGGGGAGGTAGTGA
Scypha      TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CCGACACGGGGAGGTAGTGA
Tetilla     TAGGGTTC-ATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCCCGCAAATTACCCAATC CCGAGTCGGGGAGGTAGTGA
Tripedali   TAGGGTTCGAATTCCGGAGAG GGAGCCTGAGAAATGGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC CTGACACGGGGAGGTAGTGA
Trichopla   TAGGGTTCGATTCCGGAGAG GGAGCCTGAGAAACGGCTAC CACATCCAAGGAGGCAGCA GGCGCGCAAATTACCCAATC C-GACACGGGGAGGTAGTGA
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Anthopleu  CAAGAAATAACAAATACAGGG  CTTTTCT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Anemonel   CAAGAAATAACAAATACAGGG  CTTTTCT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Lepidisis  CGAAAAATAACAAATACAGGG  CTTTTTC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAC-CTCTT-AACGAGGA  ACGATTGGAGGGGCAAGTCTG
Acanthogo  CAAAAAATAACAAATACAGGG  CTTTTTC-AAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CTCTT-AACGAGGA  CCAATTGGAGGGGCAAGTCTG
Bellonell  CAAAAAATAACAAATACAGGG  CTTTTTTGTAAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CTCTT-AACGAGGA  CCAATTGGAGGGGCAAGTCTG
Protoptil  CAAAAAATAACAAATACAGGG  CTCTTC--GAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CTCTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
N_bowersi  CGAAAAATAACAAATACAGGG  CTTTTC--AAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CTCTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
Stichopat  CAAGAAATAACAAATACAGGG  CTTTTTT-AAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Hormathii  CAAGAAATAACAAATACAGGG  CTTTTCT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Ceratotro  CAAGAAATAACAAATACAGGG  CTTTTCC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Phyllangi  CAAGAAATAACAAATACAGGG  CTTTTCC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Cerianthu  CAAGAAATATCGAATACGGGG  CTCTAATTTAGT-CTACGT-  -AATTGGAATGAGTACAACT  TAAAT-CCCAT-GCGGAGGA  TCCGTTGGAGGGGCAAGTCTG
Parazoant  CAAAAAATAACAAATACAGGG  CTTTTCC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
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Enallopsa  CAAGAAATAACAAATACAGGG  CTTTTAC-AAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Cerianthe  CAAGAAATAACAAATACAGGG  CTTTTCT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Zoanthid1  CAAAAAATAACAAATACAGGG  CTTTTAC-AAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Corynacti  CAAGAAATAACAAATACAGGG  CTTTTTC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
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Haloclava  CAAGAAATAACAAATACAGGG  CTTTTCT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Acanthopt  CAAAAAATAACAAATACAGGG  CTCTTC--GAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-GTCTT-AACGAGGA  ACGATTGGAGGGGCAAGTCTG
Metridium  CAAGAAATAACAAATACAGGG  CTTTTCT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Fungia     CAAGAAATAACAAATACAGGG  CTTTTTCC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Bathypath  CAAGAAATAACAAATACAGGG  CTTTTTTT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Taiaroa    CAAAAAATAACAAATACAGGG  CTTTTTTGTGTAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CTCTT-AACGAGGA  CCAATTGGAGGGGCAAGTCTG
Tubipora   CAAAAAATAACAAATACAGGG  CTTTTTTGTAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-CTCTT-CACGAGGA  CCAATTGGAGGGGACAAGTCTG
Pavona     CAAGAAATAACAAATACAGGG  CTTTTAC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Stomphia   CAAGAAATAACAAATACAGGG  CTTTTAC-AAGT-CTT-GT-  -AATTGGAATGAGTACTACT  TAAAT-CCTTT-CACCGAGGA  TCCATTGGAGGGGCAAGTCTG
Discosoma  CAAGAAATAACAAATACAGGG  CTTTTAC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Palythoa   CAAAAAATAACAAATACAGGG  CTTTTTTT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Antipathe  CAAGAAATAACAAATACAGGG  CTTTTTTT-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
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Flosmaris  CAAGAAATAACAAATACAGGG  CTTTTCC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  ACCATTGGAGGGGCAAGTCTG
Rhizopsam  CAAGAAATAACAAATACAGGG  CTTTTCC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Tubastrae  CAAGAAATAACAAATACAGGG  CTTTTCC-AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAATTCCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
Umbellula  CGAAAAATAACAAATACAGGG  CTCTAC--GAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAA--CCTCTCTCCGAGGA  ACTATTGGAGGGGCAAGTCTG
Renilla    CGAAAAATAACAAATACAGGG  CTCTTC--GAGT-CTT-GT-  -AATTGGAATGAGTACAATT  TAAAT-GTCTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
Dendro2    CGAAAAATAACAAATACATGG  CTTTTC--AAGT-CTT-GT-  -AATTGGAATGAGTACAACT  TAAA--CCTCTTAACGAGGA  ACAATTGGAGGGGCAAGTCTG
Briareum   CAAAAAATAACAAATACAGGG  CTTTC--GNAGT-CTT-GT-  -AATTGGAATGAGTACAATA  TAACA-CCTTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
Mnemiopsi  CAATAAAATAACGTTGCCAGGC  G----CC-AACGGCTT-CTG  CAGTCGGAATGAGTACAATT  TAAAT-CTCTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
Selaginop  CAAGAAATAACGGATACGGGG  TCTTCAC-AGGT-CTC---G  CAATCGGAATGAGTACAATT  TAAAT-CCTTT-AACGAGGA  TCCAATGGAGGGGCAAGTCTG
Beroe      CAATAAATAACGTTGCCAGGC  G----CC-AATGGCTT-CTG  CAGTCGGAATGAGTACAATA  TAACA-CCCTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
Scypha     CGATAAATAACAAATGCAGGA  CTCTAAC-GAGT-CTT---G  CAATTGGAATGAGTACAATT  TAAAC-CCCTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
Tetilla    CAATAAATAACAAATGCTGGG  CTCTT--GTAGT-CTG---G  CAATTGGAATGAGTCCAATC  TAAAT-CCCTT-AACGAGGA  ACAATTGGAGGGGCAAGTCTG
Tripedali  CAAGAACTAACAATATGGGGG  CCTTTCTGGGTCT-CAT----  -AATTGGAATGAGTACAATT  TAAA--CCCTT-AACGAGGA  TCTATTGGAGGGGCAAGTCTG
Trichopla  CAAGAAATAACGAATACGGGG  CCAT-CTGG----CTTC--G  TAATCGGAATGAGTACAATT  TAAAT-CCTTT-AACGAGGA  TCCATTGGAGGGGCAAGTCTG
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Anthopleu   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGACTT  CGGGGGT-GGGCG--CCGGTC
Anemonel    GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGA-CGGCGGGGCCGGTC
Lepidisis   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGG-AGCGGCGCGGTTGGTC
Acanthogo   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGCTCGACGGGCCACGGTC
Bellonell   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TTGTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGG-CTCCACGGCGGACGGGTC
Protoptil   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TTGTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGG-CGGCGCGGGTTGGTC
N_bowersi   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TACTAATAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGACTT  CGGGA-CGGTGCGGGTCGGTC
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Phyllangi   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCCGGGCCGGTC
Cerianthu   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGTA-GCATCGGATGGTC
Parazoant   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGTCTTTTCGGTC
Enallopsa   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCCCGGCCGGTC
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Dactylant   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCCCGGCCGGTC
Haloclava   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGA-CGGCGCGGGTCGGTC
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Metridium   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCCCGGCCGGTC
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Bathypath   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TTGTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCACGGCCGGTC
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Pavona      GTGGCCAGCACCCGCGG--TA  GTTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGTTCGGCCGGTC
Stomphia    GTGGCCGGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGACTT  CGGGG-CGACACGGCCGGTC
Discosoma   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCAGCTCGGC-GGTC
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Antipathe   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCACGGCCGGTC
Cirripath   GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAT-GGCACGGCCGGTC
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Umbellula   GTGGCCAGCAGTCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TACTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGA-CGGCGCGGGGTCGGTC
Renilla     GTGGCCAGCAGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TACTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGA-CGGCACGGCCGGTC
Dendro2     GTGGCCAGCAGCCGCGGG--TA  ATTCCAGCTCCAATAGCGTA  TACTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGA-TCGGCCGGGTCGGTC
Briareum    GTGGCCAGCAGCCGCGGG--TA  ATTCCAGCTCCAATAGCGTA  TACTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGA-CGGCACGGCCGGTC
Mnemiopsi   GTGGCCAGCAGCCGCGGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGA-TCGGCGGGGTGGTC
Selaginop   GTGGCCAGCAGCCGCGGG--TA  ATTCCAGCTCCATTAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGTGT-GGGCCAGTCGGTC
Beroe       GTGGCCAGC-AGCCGCG--TA  ATTCCAGCTCCAATAGCGTA  TAT-AAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGAACCGGCCGA-TTGGTC
Scypha      GTGGCCAGCCAGCCGCGGGGGTA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGACGGGAGCTC-ATGGTC
Tetilla     GTGGCAGGCCAGCCGCGGGGTA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGGG-CAGCCCGGCCGGTC
Tripedali   GTGGCCAGC-AGCCGCGGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGGTTGGAGTTG-ACGGTC
Trichopla   GTGGCCAGC-AGCCGCGG--TA  ATTCCAGCTCCAATAGCGTA  TATTAAAGTTGTTGTTGCAGTTA  AAAAGCTCGTAGTTGGGATTT  CGGAATGAATCTG-ACGGTC
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Anthopleu  CGCCGC-AA-GTGTGTC---   ACTGGCCCGGGCCGGCTC   TTCTTCGCAAAGACT-GCGT   GTGCTCTTGACTGAGTGTGT   GC-AGGTA-CTTGCGACGTT
Anemonel   CGCCGC-AA--GTGTT---    ACTGACCCGGGCCGGTTC   TTCTTCGCCAAAGACT-CCAT  GTGCTCTTAACTGAGTGTGT   GAGA-GGA-CTTGCG-CGTT
Lepidisis  AGCCGC-AAGGTATGTC---   ACTGGCCGAGCTGTTC     TTCGTTCGCCAAAGACT-GCGC GTGCTCTTAGTTGAGTGTGC   GC-A-GGA-TACGCGACGTT
Acanthogo  AGCCGC-AAGGTATGTC---   ACTGTCGACGTTGGCC     TTCTTCGCGGCCAGACT-TTGC GTGCTCTTAACTGAGTGTGC   GTT--GGA-TACGCGACGTT
Bellonell  AGCCGC-AAGGTATGCC---   ACTGTCGACGTTGGCC     TTCTTCGCGGCCAGACT-ACGT GTGCTCTTAATTGAGTGTGC   GTT--GGA-TTTGCGACGTT
Protoptil  AGCCGC-AAGGTATGTT---   ACTGGCCCGGCTGTTC     TTCTTCGCCAAAGACT-ACGT  GTGCTCTTAATTGAGTGTGC   GT-A-GGA-TTTGCGACGTT
N_bowersi  AGCCGC-AAGGTATGTC---   ACTGGCCGGCCATGTTC    CTCTTCGCAAAGACT-GCTC   GTGCTCTTAGCTGAGTGTGG   GC-A-GGA-TTCGCGACGTT
Stichopat  AGCCGC-AAGGTGTGTC---   ACTGGCCCGGGCTGTTC    TTCTTCGCAAAGACT-GCGT   GTGCTCTTAGCTGAGTGTGC   AC-A-GGA-TTTGTGACGTT
Hormathii  CGCCGC-AAGGCGTGTT---   ACTGGACCGGGCTGTTC    TTATTCGCAAAGACT-GCGT   GTGCTCTTAACTGAGTGTGT   G--TA-GGA-CTTGCGACGTT
Ceratotro  TGCCGC-GAGGTACGTC---   ACTGGCCGGAGCTGTTC    TTCCTTCGCGAAGACC-GCGT  GTGCTCTTGACTGAGTGTGC   GCG--GGA-TCCGCGACGTT
Phyllangi  TGCCGC-AAGGTATGTT---   ACTGGCCGGAGCTGTTC    TTCCTTCGCAAAGACT-GTGT  GTGCTCTTGACTGAGTGTGC   AT-A-GGA-TCTTCAGCGTT
Cerianthu  CGCCGC-AAGGCGTTGA---   ACTGGCCGGTGTAGCC     TTTTGTTCGCGGCCAGACC-CTGC GTGCTCTTCGTTGAGTGTGT AGG--GGA-TCCGTCACGTT
Parazoant  CACCGC-AAGGTGTGTC---   ACTGGAGGAGCTGTTC     TTCTTCGCAAAGACC-GCGT   GTGCTCTTAGCTGAGTGTGC   GC-A-GGA-TTCGCGACGTT
Enallopsa  TGCCGC-AAGGTATGTC---   ACTGGCCGAGCTGTTC     TTCCTTCGCAAAGACT-GTCT  GTGCTCTTAACTGAGTGTGC   TC-A-GGA-TCTGCGACGTT
Cerianthe  CGCCCCCTTGATAGAGGTG    AGCTACTGGCCGGCGCGTCC TTCCCGCGGCCAGACC-CGGT  GTGCTCTTAACTGAGTGTGC   GG-G-GGA-TTCGCCACGTT
Zoanthid1  CACCGC-AAGGTGTGTC---   ACTGAGAGAGCTGTTC     TTCTTTCGCGGAGACC-TGGT  GTGCTCTTAACTGAGTGTGC   GTC--GGA-TTTGCGACGTT
Corynacti  CGCCGC-AAGGTGTGTTT--   ACTGGCCGGGCTGTTC     TTCCTTCGCGGAGACC-GTGT  GTGCTCTTAACTGAGTGTGC   TCG--GGA-TCTGCGACGTT
Dactylant  CGCCGC-AAGGTGTGTT---   ACTGGCCGGGCCGCTC     TTCTTCGCAAAGACT-GCGT   GTGCTCTTGACTGAGTGTGC   GT-A-GGA-CTTGCGACGTT
Haloclava  CGCCGA-GAGGTGTGTC---   ACTGGCCGGGGCCGCTC    TTCTTCGCAAAGACT-GCGT   GTGCTCTTAGCTGAGTGTGC   GC-A-GGA-CTTGCGACGTT
Acanthopt  AGCCGC-AAGGTATGCA---   ACTGGCCTCGCCTTCC     TTTTCCCGGCCAGACT-GCGC  GTGCTCTTAACTGAGTGTGC   GT-A-GGA-CTTGTGACGTT
Metridium  CGCCGC-AAGGCGTGTTT--   ACTGGCCGAGCTGTTC     TTCTTGGGGCCAGACT-GCAT  GTGCTCTTAACTGAGTGTGT   GC-A-GGA-TTCGTCACGTT
Fungia     TGCCGC-AAGGTATGTT---   ACTGGCCGGGCTGTTC     TTCCTTCGCAAAGACT-GTGT  GTGCTCTTAACTGAGTGTGC   GG-G-GGA-TTCGCCACGTT
Bathypath  CGCCGC-AAGGTGTGCT---   ACTGGCCCGGGTGTTC     TTCTTTCGCAAAGACT-GCGT  GTGCTCTTAACTGAGTGTGC   TC-A-GGA-TTTGTGACGTT
Taiaroa    AGCCGC-AAGGTATGTC---   ACTGTCGGCGGTGTTC     TTCTTTCGCGGCCAGACT-TCGC GTGCTCTTAACTGAGTGTGC  GTC--GGA-TACGCGACGTT
Tubipora   TGCCGC-AAGGTATGTT---   ACTGGCCGAGCTGTTC     TTCCGCCGCAAAGACT-GCGT  GTGCTCTTAACTGAGTGTGC   TC-A-GGA-TCTGCGACGTT
Pavona     TGCCGC-AAGGTATGTT---   CACTGGCCGGTGTGCCC    TTCCTTCGCGGACACC-GGGT  GTGCTCTTGACTGAGTGTGC   GC-G-GCA-GCCGCGACGTT
Stomphia   CGCCGC-GAGGCGTGTT---   ACTGGCCCGGGCTGTTC    TTCTTTCGCGGCCAGACT-GTGT GTGCCCTTAACTGAGTGTGC  TC-A-GGA-TCTGCGACGTT
Discosoma  CGCCGC-AAGGTGTGCT---   ACTGGACCGGGGCTGTTC   TTCCGCCGCAAAGACT-GCGT  GTGCTCTTGACTGAGTGTGC   GT-A-GGA-TTTGTGACGTT
Palythoa   CACCGC-AAGGTGTGC---    ACTGGGTGGGGCTGTTC    TTCTTCGCGAAGACT-GCGT   GTGCTCTTAACTGAGTGTGC   AC-A-GGA-TTTGTGACGTT
Antipathe  CGCCGC-AAGGTGTGCT---   ACTGGCCGCGGGCTGTTC   TTCTTCACAAAGACT-GCGT   GTGCTCTTAACTGAGTGTGC   GC-A-GGA-TTTGTGACGTT
Cirripath  CGCCGC-AAGGTGTGTC---   ACTGGCCGCGGGCTGTTC   TTCTTCGCAAAGACT-GGGT   GTGCTCTTAACTGAGTGTGC   AC-A-GGA-TTTGTGACGTT
AntipatGE  CGCCGC-AAGGTGTGCT---   ACTGGCCCGGGCTGTTC    TTCTTCGCAAAGACT-GGGT   GTGCTCTTAACTGAGTGTGC   AC-A-GGA-TTTGTGACGTT
EpiactisG  TGCCGC-AAGGTATGTT---   ACTGGGCCGGAGCTGTTC   TTCCCCGCAAAGACCTCGCGT  GTGCTCTTAACTGAGTGTGC   C--A-GGA-CCTGCGACGTT
Flosmaris  CGCCGC-GAGGCGTGTC---   ACTGGCCGAGCTGTTC     TTCTTCGGCAAAGACT-GGGT  GTGCTCTTAACTGAGTGTGC   GT--GGA-CTTGCGACGTT
Rhizopsam  TGCCGC-AAGGTATGTT---   ACTGGCCGAGCTGTTC     TTCCCCGCAAAGACT-GTGT   GTGCTCTTAACTGAGTGTGC   GGTA-GGA-CTTGCGACGTT
Tubastrae  TGCCGC-AAGGTATGTT---   ACTGGCCCGAGCTGTTC    TTCCTTCGCAAAGACT-GTGT  GTGCTCTTAACTGAGTGTGC   TC-A-GGA-TCTGCGACGTT
Umbellula  AGCCGC-AAGGTTTGTT---   ACTGGCCGCGGCCTACC    CTATTCGCGGAAGACT-CCGT  GTGCTCTTCACTGAGTGTGC   TC-A-GGA-TTTGTGGCGTT
Renilla    AG-CCGAAAGGTGTGTC---   ACTGGGCGGGCTGTCC     TTCTTCGCGAAAGACCTCGCGT GTGCTCTTAACTGAGTGTGC   GTT--GGA-TTTGTGGCGTT
Dendro2    AATCCGCAAGGCATGCC---   ACTGGCTCCGTTGTCC     TTCTTCGGCGAAGACT-GCGC  GTGCTCTTAACTGAGTGTGC   GTT--GGA-CTTGCGACGTT
Briareum   AG-CCGCAAGGTATGTC---   ACTGGCCCGCGGCGGTCC   TTCTTCGCCAAAGACC-GCGT  GTGCTCTTAACTGAGTGTGC   AT--GGAATTTGCGACGTT
Mnemiopsi  CGTCCTCT-GGATCGTGT--   ACTGATCGGTCGTGTTC    TTCTTTCGGCGAAGACT-GCAC GTGCCCGTCCGGGGTGTGT    GNG--GGA-TTCGCGACGTT
Selaginop  GGCCGC-AAGGCCTGTT---   ACTGACTGGTTCGCTC     TTCTTTCGGCGAAGACC-GCGT GTGCCCGTCCGCTGGGTGTGT  GTATTGGA-TTTGAGACGTT
Beroe      CGTCCTC-TGGATCGTGT--   ACTGTGCTGTTCTGTT     CTTCTTTCGTTCGGAAGACT-GGGT GTGCTCTTCACTGAGTGTGC TCG--GGA-TTCGCGACGTT
Scypha     CGCCGGCAGCAAGT----    ACTGGTCGGGGC--GCTC   TTCCCTCCGAAGGCTTCGAC   TGTTCTTCATTGATTGTAANGGTC GT-A-GGA-TTCGGGACGTT
Tetilla    TGCCGCAGCAAGT------    ACTGGTCGGTTCTGTT     TTCCTCTCGAAGGCCTCGGCA  GTGCTCCGTCCGGGGGTGT    GA-A-GAG-TTCGGGACGTT
Tripedali  TGCCGCAGCAAGT------    ACTGTCCACTCTGT-C     CTTCTTTCTTTCGGAAGACTTCAC ATATCCTTAACTGGCGTTGT GT-A-GGA-TTTGTGGACGTT
Trichopla  CGCCT-AACGGTGAGT---    ACTGGATGATTTGT-T     CTTCTTCTTGAGGGCTGCAT   AIGCTCTTAATTGAGTGTGT   GT-A-GGA-CTTAAGACTTT
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Anemonia G  TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTG-- -GGTTC-TATTTT--GTTGG
Anthopleu   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTG-- -GGTTC-TATTTT--GTTGG
Anemonel    TACTTTGAAAAAATTAGAGT  GTTCAAAAGCAGGCCCA--GCG CCTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Lepidisis   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTC--GCG CTTGGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Acanthogo   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTC--GTG CTTGGGATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTTCCGTTGG
Bellonell   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTT--GTG CTTGGATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTTCCGTTGG
Protoptil   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTT--GTG CTTGGATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Protopti1   TACTTTGAAAAAAATTAAAGT GTTCAAAAGCAGGCCTT--GTG CTTGGATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
N_bowersi   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTG--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Stichopat   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Hormathii   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCCA--GCG CCTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Ceratotro   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCCG--GCG CTTGGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Phyllangi   TACTTTGAAAAAAATTAGAGT GTTCAGAGACAGGCCCA--GAG CTTGGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Cerianthu   TACTTTGAAAANTTAGAGT   GTTCAAAGCAGGCCGCGCGG CTCGGATACATAAGCATGGA ATAATGGAATAGGACTCCTC CGGGTTC-TAGTTC--GTTGG
Parazoant   TACTTTGAAAAANTTAGAGT  GTTCAAAAGCAGGCCCGC--CG CTTGGAATACATAAGCATGGA ATAATGGAATAGGACGTC-- -GGTTC-TAGTTC--GTTGG
Enallopsa   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Cerianthe   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCGAT-CGGG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTCT-- -GGTTC-TATTTT--GTTGG
Zoanthid1   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Corynacti   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--ACG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTTCCGTTGG
Dactylant   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Haloclava   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Acanthopt   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTT--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
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Fungia      TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTCT--GTTGG
Bathypath   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Taiaroa     TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGGCTT--GTG CTTGGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTTCCGTTGG
Tubipora    TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTC--GCG CTTGGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTTCCGTTGG
Pavona      TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACGTAAGCATGGA ATGATGGAATAGGACC---C CGGTTC-TATTTT--GTCGG
Stomphia    TACTTTGAAAAAAATTAGAGT ATTCAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATGATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Discosoma   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACCGT-- CGGTTC-TATTTT--GTTGG
Palythoa    TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCCC--ACG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Antipathe   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Cirripath   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
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Epiactisc   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CCTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Flosmaris   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTG-- -GGTTC-TATTTT--GTTGG
Rhizopsam   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Tubastrae   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCA--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Umbellula   TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCGGTGTG CTTGAATGCGTAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Renilla     TACTTTGAAAAAAATTAGAGT GTTCAAAAGCAGGCCTC--GCG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTC--GTTGG
Dendro2     TACTTTGAAGAAAATTAGAGT GTTCAAAGCAGGGCTG--GAG CTTGAATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Briareum    TACTTTGAAAAAAATTAGAGT GTTCAAAGCAGGCC---TGTG CTTGGATACATAAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Mnemiopsi   TACTTTNAAAAATTAGAGT   GTTCAAAAGCAGGCAG--TCG CTNGAATATCTCAGCATGGA ATAATAGAATAGGACTTT-- -GGTCT-TATTTT--GTTGG
Selaginop   TACTTTGAAAAAATTAGAGT  GTTCAAGGGCAGGCTTTGAGG CTTGAATATCTCAGCATGGA ATAATAGAATAGGACCTC-- -GGTCCCTATTTC--GTTGG
Beroe       TACTTTGAAAAAAATTAGAGT GTTCAAGGCAGGCATT--CG  CTTGAATATCTCAGCATGGA ATAATAGAATAGGACTTT-- -GGTCT-TATTTT--GTTGG
Scypha      TACTTTGAAAAAATTATAGAGT GTTCAAAGCAGGCCCT--GG CTTGAATACATTAGCATGGA ATAATGGAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
Tetilla     TACTTTGAAAAAAATTATAGAGT GTTCAAGGCAGGCCG---TCG CTTGA-TACATTAGCATGGA ATAATGAAGAGACCCTC-- -GGTCC-TATTTT--GTTGG
Tripedali   TACTTTGAAAAAAATTAGAGT GTTCAAAGGCAAGCATACTAG CCTGA-TACATTAGCATGGA ATAATGGAAATAGGACTTT-- -GGTCC-TATTTT--GTTGG
Trichopla   TACTGTGAAAAAATTAGAGT  GTTCAAAGCAAGCAGGCCCA--TCG CTTGAATACCTGAGCATGGA ATAATAAAAATAGGACTTT-- -GGTTC-TATTTT--GTTGG
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Anthopleu    TTTCGTGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Anemonel     TTTC-TGGAACC-GANGTAA  TGATTGAAAGGGANNGTTGG  GGGNATT--CGTATTTCGTT  GTNAGAGGTGANATTCTTGG  ATTTACGAAAGACGAACTAC
Lepidisis    TTTC-TCGAACC-GAAGTAA  TGATGAAATAGGGACAGTTGG GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAA
Acanthogo    TTTC-TGGAACC-GAAGTAA  TGATTAAATAGGGACAGTTGG GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAA
Bellonell    TTTC-TGGAACC-GAAGTAA  TGATTAATAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAA
Protoptil    TTTG-TAGAACC-GAAGTAA  TGATTAATAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTGCGAAAGACGAACTAA
N_bowersi    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGAGGGACAGTTGG GGGCATT--CGTATTTCGTT GTCAGAGGTGAAATTCTTGG  ATTTGCGAAAGACGAACTAC
Stichopat    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Hormathii    TTTC-TGGAACC-GAAGTAA  TGATTAAAAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
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Corynacti    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Dactylant    TTTC-TGGAACC-GAAGTAA  TGATTAAGGGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Haloclava    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
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Metridium    TTTC-TGGAACC-GAAGTAA  TGATTAAAAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Fungia       TTTC-TGGAACC-GAAGTAA  TGATTAAGAGAGAGACAGTTGG GGGCATT--CGTATTTCGTT GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Bathypath    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAA
Taiaroa      TTTC-TGGAACC-GAAGTAA  TGATTAATAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAA
Tubipora     TTTC-TGGAACC-GAAGTAA  TGATTAATAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Pavona       TTTC-TGGAACC-GAAGTAA  TGATTAAGAGAGGACAGTTGG GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Stomphia     TTTC-TCGAACC-GAAGTAA  TGATTGAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Discosoma    TTTC-TGGAACC-GAAGTAA  TGATTAACAGAGATAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Palythoa     TTTC-TGGAACC-CACGTAA  TGATTAACAGAGATAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Antipathe    TTTC-TGGAACC-GAAGTAA  TGATTAAAAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Cirripath    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
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EpiactisG    TTTC-TGGAACC-CA-GTAA  TGATTTAGAGAGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Flosmaris    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGAGAGACAGTTGG GGGCATT--CGTATTTCGTT GTCAGAGGTGGAATTCTTGG  ATTTACGAAAGACGAACTAC
Rhizopsam    TTTC-TGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Tubastrae    TTTCT-TGGAACC-GAAGTAA TGATTGACAGAAAATGATTGG GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ACCTGCGCGAAAGACGAACTAA
Umbellula    TTTC-TGGAACC-GAAGTAA  TGATTGAGAGAGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATCTGCGGAAAGACGAACTAC
Renilla      TTTG-TAGGACC-GAAGTAA  TGATTAATAGGGACAGTTGG  GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Dendro2      TTTG-TAGGACC-GAAGTAA  TGATTAACAGAGACAGTTGG  GGGCATT--CGTATTTCGGT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACTAC
Briareum     TTTC-TGGAACC-GAAGTAA  TGATTAAGAGGGACAGTTGG  GGGCATT--CGTATTTCATT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACCAG
Mnemiopsi    TTTT-ACGGACC-GAAGTAA  TGATTAGAGGGACAATTGG   GG-CATC--CGTATTTCGTA  GTCAGAGGTGAAATTCTTGG  ACCTACGAAAGACGAACAAC
Selaginop    TTTC-GAGACC-GAAGTAA   TGATTAATAGGGACAGTTGG  GGG-ATT--CGTATTTCATT  GTCAGAGGTGAAATTCTTGG  ATTTA-GAAAGACGAACTTC
Beroe        TTTC-GAGACC-GAAGTAA   TGATTAATAGGGACAGTTGG  GGG-ATT--CGTATTTCATT  GTCAGAGGTGAAATTCTTGG  ATTTATTGGAAGACGAACACAC
Scypha       TTTC-GGAACC-RAGGTAA   TGACTAATAGGGACAGTTGG  GGGCATT--CGTATTTCAATT GTCAGAGGTGAAAT-CTCGG  ATTTATGTGAAGACGAA-AAG
Tetilla      TTTCTAGGG-CC-GAAGTAA  TGATCAAGAGGGAGACAGTTGG GGGCATT--CGTATTTAATT GTCAGAGGTGAAAT-CTCGG  ATTTATGAAAGACGAACAAC
Tripedali    TTTCCAGGA-CC-GACGTAA  TGATTAAGAGGGAACAGTTGG GGGCATT--CGTATTTCGTT  GTCAGAGGTGAAATTCTTGG  ATTTACGAAAGACGAACAAC
Trichopla    TTTC-GGAACC-GAAGTAA   TGATTAATAGGGACAGTTGG  GGGCATTCGCGTACTTCATT  GTCAGAGGTGAAATCTCTTGG ATTTATGAAAGACGAACAAC
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AnemoniaG    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGCTCGAAG  ACGATCAGATACCGTCCTAG  TTATAACCATAAAACGATGCC
Anthopleu    TGCGAAAGCATTTGTCCAAGA ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGCTCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Anemonel     TGCGAANGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Lepidisis    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Acanthogo    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Bellonell    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Protoptil    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGG---GAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
N_bowersi    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Stichopat    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Hormathii    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAN  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Ceratotro    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CNAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Phyllangi    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Cerianthu    TGCGAAAGCATTTGCCAAGA  ACGCTCTCATTAATCAAGAA  CGATAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCGTAAAACGATGCC
Parazoant    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGTTCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Enallopsa    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Cerianthe    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Zoanthid1    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGCTCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Corynacti    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Dactylant    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Haloclava    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Acanthopt    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Metridium    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Fungia       TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Bathypath    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Taiaroa      TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCGTAAAACGATGCC
Tubipora     TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Pavona       TGCGAAAGCATTTGCCAAGA  GTGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Stomphia     TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Discosoma    TGCGAAAGCATTTGCCAAGA  GTGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGCTCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Palythoa     TGCGAAAGCATTTGCCAAGA  GTGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGCTCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Antipathe    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Cirripath    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
AntipatGE    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGCTCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
EpiactisG    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAGG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Flosmaris    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Rhizopsam    TGCGAAAGCATTTGCCAAGA  ATGTTTTCGTTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Tubastrae    TGCGAAAGCATTTGCCAAGA  GCGTTTGCGTTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCGTAAAACGATGCC
Umbellula    TGCGAAAGCATTTGTCCAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Renilla      TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Dendro2      TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATGATCAAGAA CGAAAGTTAGAGGATCGAAG ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACGATGCC
Briareum     TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCCTAG  TTCCAACCATAAAACGATGCC
Mnemiopsi    TGCGAAAGCATTTGCCAAGG  ATGTTTTCATTAATCAAGAA  CGAAAGTTGGGGGTTCGAAG  ACGATCAGATACCGTCGTAG  TTCCAACCGTAAACGATGCC
Selaginop    TGCGAAAGCATTTGCCAAGG  GTGTTTTCATTAATCAAGAA  CGAAAGTTGGAGGCTCGAAG  ACGATCAGATACCGTCCTAG  TTCCAACCATAAAACTATGCC
Beroe        TGCGAA-GCATTTGCCAAGG  ATGTTTTCATTAATCAAGAA  CGAAAGTTGGAGGGTTCGAAG ACGATCAGATACCGTCCTAG  TTCCAACCATAAAACGATGCC
Scypha       TGCGAAAGCATTTGCCAAGG  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGGTTCGAAG ACGATCAGATACCGTCGTAG  TTCCAACCATAAAACTATGCC
Tetilla      TGCGAAAGCATTTGCCAAGG  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGATCGAAG  ACGATCAGATACCGTCGTAG  TCCCAACCATAAAACGATGCC
Tripedali    TGCGAAAGCATTTGCCAAGA  ATGTTTTTTCATTAATCAAGAA CGAAAGTTAGAGGATCGAAG ACGATCAGATACCGTCCTAG  TTCTAACCATAAAACTATGCC
Trichopla    TGCGAAAGCATTTGCCAAGA  ATGTTTTCATTAATCAAGAA  CGAAAGTTAGAGGGTTCGAAG ACGATCAGATACCGTTGTAG  TTCTAACCATAAAACGATGCC
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AnemoniaG   GACTAGGGATCAGAGAGTGT TATTGGGATGACCTCTTTGGC ACCTTAGGGAGAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Anthopleu   GACTAGGGATCAGAGAGTGT TATTGGGATGACCTCTTTGGC ACCTTAT-GGAAACCAAA-G  TTTTTGGGTTCCGGGGGG-AAG TATGGTTGCAAAATCTGAAAC
Anemonel    GACTAGGGATCAGAGAGTGT TATTGGGATGACCTCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Lepidisis   GACTAGGGATCGGCGGGTGT TATTGGTATGACCCCGTCGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAGTCTGAAAC
Acanthogo   GACTAGGGATCAGCGAGTGT TATTTGATGACCTCGTTGGC  ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Bellonell   GACTAGGGATCAGCGAGTGT TATTTGATGACCTCGTTGGC  ACCTTATGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Protoptil   GACTAGGGATCAGCGGGTGT TATTGGGATGACCCCGTTGGC ACCTTATGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
N.bowersi   GACTGGGGATCAGCGGATGT TATTGTATGACTCCGTTGGC  ACCCTAGGGAAAACCAAA-G  TGTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Stichopat   GACTAGGGATCAGAGAGTGT TATTGGGATGACCCCGTTGGC ACCTTATGGGAAAACCAAA-G TCTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Hormathii   GACTAGGGATCAGAGAGTGT TATTGGGATGACCTCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Ceratotro   AACTAGGGATCGGACGGTGT TATTGGGATGACCCGTTTGGC ACCTTGTGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Phyllangi   AACTAGGGATCAGAGAGTGT TATTGGGATGACCCCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Cerianthu   GACTAGGGATCGGGAGAGGGA CAT-GCAT-ACCCTTTCGGC ACCTTGTGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Parazoant   GACTAGGGATCGGGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAGTCTGAAAC
Enallopsa   AACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Cerianthe   GACTAGGGATCGGGAGAGTGT TATTTCAGGACCTCTTCGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Zoanthid1   GACTAGGGATCGGGAGAGTGT TATTGTATGACCCCTTTGGC  ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAATCTGAAAC
Corynacti   AACTAGGGATCAGAGAGTGT TATTGGGATGACCTCCTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Dactylant   GACTAGGGATCAGGGAGTGT TATTGGGATGACCTCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Haloclava   GACTAGGGATCGGCGCGGTGT TAATTGATGACCCCGTCGGC ACCTTAGGGAAAACCAAA-G  TGTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Acanthopt   GACTAGGGATCAGAGAGTGT TATTGGGATGACCTCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Metridium   GACTAGGGATCAGAGAGTGT TATTGGGATGACCTCTTTGGC ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Fungia      AACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TCTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Bathypath   GACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TCTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Taiaroa     GACTAGGGATCAGCGAGTGT TATTTGATGACCTCGTTGGC  ACCTTATGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Tubipora    GACTTGGGATCAGCGGGTGT TATTTGGGATGACCCCGTTGGC ACCATATGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAGAC
Pavona      AACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Stomphia    GACTAGGGATCGGGGAGTGT TATTGGGATGACCTCCTCGGC ACCTCACGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Discosoma   AACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTTCGGGAAAACCAAA-G TGTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Palythoa    GACTAGGGATCGGTGGGTGT TATTGTATGACTCTCTTTGGC ACCTTAGGGAAAACCAAA-G  TCTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Antipathe   GACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TCTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Cirripath   GACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TCTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
AntipatcE   GACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TCTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
EpiactisG   GACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TTTTTGGGTTCNCGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Flosmaris   GACTAGGGATCAGAGGGTGT TATTGGGATGACCTCTTTGGC ACCTTATGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Rhizopsam   AACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTATGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Tubastrae   AACTAGGGATCAGAGGGTGT TATTGGGATGACCCCTTTGGC ACCTTAAGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Umbellula   GACTAGGGATCGGCGGGTGT TATTTCATGACTCCGTCGGC  ACCTTATGGGAAAACCAAA-G TTTTTGGGTTCCNCGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Renilla     GACTAGGGATCGGCGGGTGT TATTGGATGACCCCGTTGGC  ACCTTAAGGGAAAACCAAA-G TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Dendro2     AACTAGGGATCAGCGGGTGT TATTGTATGACCCCGTTGGC  ACCTTAGGGAAAACCAAA-G  TTTTTGGGTTCCGGGGGGGAG TATGGTTGCAAAAGCTGAAAC
Briareum    GACTAGGGATGGCGAGTGT TATTGTATGACCTCGTCGGC   AGGCTATGAGAAAATCAAA-G ACTTTCGGGTTCCGGGGGAAG TATGGTTCCCAAGNATGAAAC
Mnemiopsi   GTCTGCGGATCGGAGTCGC  TCAATTAAGGCTCCTTCGGC  ACCTCACGGGAAAACCAAA-G TGTTTGGGGTTCCGGGGGGGAG TATAGTCGCAAGGCCGAAAC
Selaginop   GACTAGGGATCAGCGGGTGT TATTGTGCCAACCCCGTTGGC AGGCTATGAGAAAATCAAA-G ACTTTCGGGTTCCGGGGGGGAG TATGGTTCGGAAGGAATGAAAC
Beroe       GTCTGCGGATCGAGGTCGC  TCACATAAGGCTCCTTCGGC  AGGCTATGAGAAAATCAAA-G ACTTCGGGTTCCGGGGGGGAG TATGTTCGGAAGA-TGAAAC
Scypha      GACTAGGGATGCGGTGGATGT TATTAAATGACTCCATCGGC ACCTTATGCAGAAAATCAAA-G TTTTTGGGTTCCGGGGGGGAG TATAACGCAAGATCGGAAAC
Tetilla     GACTAGGGATCGGCGGGTGT TAGCGTCTGACCCCGTCGGC  ACCTTGGCGAGAAAATCAAGAG TCTTTGGGGTTCCGGGGGGAAG TATGGTCGCAAGGCCGAAAC
Tripedali   GACTAGGGATCAGCGGGCGT TATGGTTATGACCCCGGTTGGC ACCTTATGGGAGAAATCAAA-G TTTTTGGGGTTCCGGGGGGGAG TATGGTTCGAAGGCTGAAAC
Trichopla   GTCTAGGGATCAGTGGGTGT TATTTATGACTCCATTGGA   ACCTTAAGGGGAAAACCAAA-G ATTTTGGGTTCCGGGGGGAAG TATGGTTGCAAAGGCTGAAAC
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Anemoniag   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG--AGC  CTG-CG-CTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Anthopleu   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGGGCA-   -TG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Anemonel    TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-ACG   -TG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Lepidisis   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGGC---   -NG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCGGACATAGGAAGGATT
Acanthogo   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTA-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Bellonell   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGGCCAG-  -TG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Protoptil   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
N_bowersi   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Stichopat   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Hormathii   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-GGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Ceratotro   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Phyllangi   TTAAAGGAATTGACGGAAGG  GCACCAAGGAGTGG-AGC     CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTGCAGGATT
Cerianthu   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Parazoant   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGGGATT
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Zoanthid1   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Corynacti   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Dactylant   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Haloclava   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Acanthopt   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Metridium   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Fungia      TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGGATT
Bathypath   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Talaroa     TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Tubipora    TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Pavona      TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGGCTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGCAGGATT
Stomphia    TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Discosoma   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Palythoa    TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCGGACATAGTAGTAGGATT
Antipathe   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Cirripath   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
AntipatGE   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AC-   -TG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGGATT
EpiactisG   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AC-   -TG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTGAGGATT
Flosmaris   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AC-   -TG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGGATT
Rhizopsam   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AC-   -TG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGGATT
Tubastrae   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AC-   --TG-CGGCTTAATTTGACTC AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGGATT
Umbellula   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGCCGAGGATT
Renilla     TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Dendro2     TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTGGCGGCTTAATTTGACTC  AACACGGGGGAAACTTACCAG  GTCCAGACATAGTAGTAGGATT
Briareum    TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGTTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTAGGATT
Mnemiopsi   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AAC   CTG-CGGCTTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGGAAGGATT
Selaginop   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG----   CTG-CGG-TTAATTTGACTC  AA--CGGGAAAACTCACCAG   GTCCAGACATAGTAGAAGGATT
Beroe       TTAAGGAATTGACGGAAGG   GCACCACCAGGAGTGG-AC-   CTG-CGG-TTAATTTGACTC  AACACGGGGGAAACTCACCAG  GTCCAGACATAGTGAGGATT
Scypha      TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGAAAACTCACCAG  GTCCAGACATAGTAGTAGGATT
Tetilla     TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTG--AGC   CTG-CG-CTTAATTTGACTC  AACACGGGGAAAACTCACCAG  GTCCGGAGACATAGTAGTAGGATT
Tripedali   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG--AGC  CTG-CGGCTTAATTTGACTC  AACACGGGGAAAACCTCACCAG GTCCAGACATAGTAGAAGGATT
Trichopla   TTAAAGGAATTGACGGAAGG  GCACCACCAGGAGTGG-AGC   CTG-CGGCTTAATTTGACTC  AACACGGGGAAAACTCACCAG  GTCCAGACATAGTGAGGATT
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Anemonia G   GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Anthopleu    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Anemone1     GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Lepidisis    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGCCTGGTT  AATTCCGTTAACGAACGAGA
Acanthogo    NACAGATTNANAG-CTCTTTT  CTTNATTCTATNNNNTGGGTGG TGCATGNCCGTTCTTAGTTG  GTGGAGTGATTGTTNTCTGGTT  AATTCCGTTAACGAACGAGA
Bellonell    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Protoptil    GACAGATTGAGAG-CTCTTTT  CTTCATTCTATGGGATGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
N.bowersi    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGATGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Stichopat    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Hormathi     GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Ceratotro    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Phyllangi    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Cerianthu    GACAGACGGAGACCCCTTT    CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGCGATTGTTGTCTGGTC  AATTCCGATAACGAACGAGA
Parazoant    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Enallopsa    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Cerianthe    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Zoanthidi    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Corynacti    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Dactylant    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Haloclava    GACAGATTGAGAG-CTCTTTT  CTTGATTCCTATGGGTGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Acanthopt    GACAGATTGAGAG-CTCTTTT  CTTGATCCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGATAACGAACGAGA
Metridium    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Fungia       GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Bathypath    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Taiaroa      GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Tubipora     GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Pavona       GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Stomphia     GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Discosoma    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Palythoa     GACAGATTGATAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Antipathe    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Cirripath    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
AntipatGE    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
EpiactisG    GACAGATTGAGAG-CTCTTTT  CTTGAATTCTATGGGTGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGAATCGTGTCTGGTT AACTCCGATAACGAACGAGA
Flosmaris    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Rhizopsam    GACAGATTGAGAG-CGCGTG   CTTGAGTCTATGGGTGGGTGG  TGCATGGCCGGGGGTTAGTTG GTGGAGTGATTGTTGTCTGGTT  AACTCCGTTAACGAACGAGA
Tubastrae    GTCAGATTGAGAG-CGCGTG   CTTGAGTCTATGGGGTTGGGTGG TGCATGGCCGTTCTTAGTTG GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Umbellula    GACAGATTGAGAG-CTCTTTT  CTTGAATTCTATGGTTGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAATGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Renilla      GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGAATCGTTGTCTGGTT AATTCCGATAACGAACGAGA
Dendro2      GACAGATTGAGAG-CTCTTTT  CTCGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGAATTGTTGTCTGGTT AATTCCGTTAACGAACGAGA
Briareum     GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Mnemiopsi    GACAGGTTGAGAG-CCCTTTT  CTTGATTTCTATGGGTGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Selaginop    GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Beroe        GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGTGGGTGG  TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Scypha       GACAGATTGAGAG-CTCTTTT  CTTGATTCTATGGGGTGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Tetilla      GACAGATTCGAGAG-CTCTTTT CTTGATTCTATGGGGTGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Tripedali    GACAGATTGAGAG-CTCTTTT  CTTGATTCCTATGGGGTGGGTGG TGCATGGCCGTTCTTAGTTG GTGGAGTGATTGTTGTCTGGTT  AATTCCGTTAACGAACGAGA
Trichopla    GACAGATTGATAG-CTCCTTT  CTTGATTCTATGGGGTGGGTGG TGCATGGCCGTTCTTAGTTG  GTGGAGTGATTTGTCTGGTT   AATTCCGTTAACGAACGAGA
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AnemoniaG   CCTTAACCTGCTAAATAGTT ACGGCCCATCGC-GATGGGGCA ACTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Anthopleu   CCTTAACCTGCTAAATAGTT ACGTCG-TCTC-GACGGGCG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Anemonel    CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGTG GCTG------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Lepidisis   CCTTGGCCTGCTAAATAGTT GGACGATTCTC-GAATCGTC CTCG------------ACTTC TTAGAGGGGACTGTTTG-GTGA TC--AACCAAAGTCAGGA--
Acanthogo   CCTTGACCTGCTAAATAGTC AGACGATTCGC-GAATCGCT CTCG------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Bellonell   CCTTGACCTGCTAAATAGTC AGACGATTCGC-GAATCGGT CTCG------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGAA--
Protoptil   CCTTGACCTGCTAAATAGTC GGGGGATTCGC-GAATCGTA CTCG------------ACTTC TTAGAGGGGACTGTTTG-GTGT TC--AACCAAAGTCAGGA--
N_bowersi   CCTTGACCTGCTAAATAGTC GGACGGATTCCC-GAATCGTC CACG------------ACTTC TTAGAGGGGACTGTTTG-GTGA TC--AACCAAAGTCAGGA--
Stichopat   CCTTGACCTGCTAAATAGTC ACGGGAATCCC-GATTCGTG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Hormathii   CCTTAACCTGCTAAATAGTC ACGGGAATCCC-GATTCGTG GCTG------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Ceratotro   CCTTAACCTGCTAAATAGTC ACGGGAATCCC-GATCGGCG GTTG------------ACTTC TTAGAGGGGACTGTTTG-GTGT CC--AACCAAAGTCAGGA--
Phyllangi   CCTTAACCTGCTAAATAGTC ACGGGAATCCC-GATTCGGCG GTTA------------ACTTC TTAGAGGGGACTGTTTG-GTAT CC--AACCAAAGTCAGGA--
Cerianthu   CCTTTACCTGCTAGTTAGCG CGGCAGTTTTC-GAACGAGC AGGA------------GCTTC TTAGAGGGGACTGTTGC-TGC GT--GAGAAAGTCAGAA--
Parazoant   CCTTAACCTGCTAAATAGTC AGCGGAATCCC-GATTCGTG ACGA------------ACTTC TTAGAGGGGACTGTTTG-GTTT TC--AACCAAAGTCAGGA--
Enallopsa   CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGTG GTAA------------ACTTC TTAGAGGGGACTGTTTG-GTGT CC--AACCAAAGTCAGGA--
Cerianthe   CCTTAACCTGCTAAATAGTC GGCCCGTTCCCGTTGGAACG GTGC-AGATGG------ACTTC TTAGAGGGGACTGTTTG-GTGT CT--AACCAAAGTCAGGA--
Zoanthid1   CCTTAACCTGCTAAATAGTC ACGGGAATCCC-GATTCGTG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TC--AACCAAAGTCAGGA--
Corynacti   CCTTAACCTGCTAAATAGTC ACGGGAATCCC-GATTCGTG GTTC------------ACTTC TTAGAGGGGACTGTTTG-GTTT TC--AACCAAAGTCAGGA--
Dactylant   CCTTAACCTGCTAAATAGTT ACGGGAATCTC-GATTCGTG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Haloclava   CCTTAACCTGCTAAATAGTT ACGGGGATCCC-GATTCGCG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TC--AACCAAAGTCAGGA--
Acanthopt   CCTTGACCTGCTAAATAGTC TGGCGGTTCGC----GAACC GTTTT-----------AGGCTTC TTAGAGGGGACTGTTCG-GTGT TT--AACCAAAGTCAGGA--
Metridium   CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGCG GTTA------------ACTTC TTAGAGGGGACTGTTTG-GTAT TC--AACCAAAGTCAGGA--
Fungia      CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGCG GTTA------------ACTTC TTAGAGGGGACTGTTTG-GTAT CC--AACCAAAGTCAGGA--
Bathypath   CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGTG GTTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT CC--AACCAAAGTCAGGA--
Taiaroa     CCTTGACCTGCTAAATAGTC AGACGATTCAC-GAATCGCT CTCG------------ACTTC TTAGAGGGGACTGTTTG-GTAT TT--AACCAAAGTCAGGA--
Tubipora    CCTTGACCTGCTAAATAGTC AGACGATTCGC-GAATCGCT CTCG------------ACTTC TTAGAGGGGACTGTTTGCGGTGT GC--AACCAAAGTCAGGA--
Pavona      CCTTAACCTGCTAAATAGTT ACGGGGATCTC-GATTCCTGC GTTA------------ACTTC TTAGAGGGGACTGTTTG-GTAT TT--AACCAAAGTCAGGA--
Stomphia    CCTTAACCTGCTAAATAGTT ACGGGAATCTC-GATCCTGC GGAT--G---------ACTTC TTAGAGGGGACTGTTTG-GTAT GC--AACCAGAGTCAGGA--
Discosoma   CCTTGACCTGCTAAATAGTT ACGCCAATCCC-GATTGGCG GTTA------------ACTTC TTAGAGGGGACTGTTTG-GTTT CC--AACCAAAGTCAGGA--
Palythoa    CCTTGACCTGCTAAATAGTC ACGGGAATCGC-GATTCGCG CT---G----------ACTTC TTAGAGGGGACTGTTTG-GTGC TT--AACCAAAGTCAGGA--
Antipathe   CCTTAACCTGCTAAATAGTC ACGGGAATCCC-GATTCGTG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
Cirripath   CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGTG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
AntipatGE   CCTTAACCTGCTAAATAGTT ACGGGAATCTC-GATTCGTG GCTA------------ACTTC TTAGAGGGGACTGTTTG-GTGT TT--AACCAAAGTCAGGA--
EpiactisG   CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGTG GT--------------AAACTTC TTAGAGGGGACTGTTTG-GTGT CC--AACCAAAGTCAGGA--
Flosmaris   CCTTAACCTGCTAAATAGTT AGGGCCAATCCC-GATTCGTG GCT-------------AACTTC TTAGAGGGGACTGTTTG-GTGT TC--AACCAAAGTCAGGA--
Rhizopsam   CCTTAACCTGCTAAATAGTT ACGGGAATCCC-GATTCGCG GTT-------------AACTTC TTAGAGGGGACTGTTTG-GTAT CC--AACCAAAGTCAGGA--
Tubastrae   CCTTAACCTGCTAAATAGTT ACC-GAATCCC-GATTCGCG GT--------------AAACTCC TTAGAGGGGACTGTTTG-GTAT CTGTAACCAGAGTCAGGA--
Umbellula   CCTTGACCTGCTAACTAGTT AGTAGATTCAC-GAATCGAC GGTG------------ACTTC TTAGAGGGGTACTGCTG-GTGT CC--AACCAAAGTCAGGAA--
Renilla     CCTTGACCTGCTAAATAGTC GGTCGGATTCAC-GAATCGGCA CTCG------------ACTTC TTAGAGGGGACTGTTTG-GTGT TC--AACCAAAGTCAGGA--
Dendro2     CCTTGACCTGCTAAATAGTC AGTCGGATTTCC-GAATCGCG CTCG------------ACTTC TTAGAGGGGACTGTTTG-GTGT TC--AACCAAAGTCAGGA--
Briareum    CCTTGACCTGCTAAATAGTC CAGCGGATTCCC-GAATCGCG CTTTGC----------ACTTC TTAGAGGGGACTATCG-GT-T TC--AAACCGATGGAAGTTTG
Mnemiopsi   CCTTAACCTGCTAAATAGTG ACACGGTTATTTTTAACCGTG AGCAATTCCAAAGTAACTTC TTAGAGGGGACTATTGG-GTGT TT--AACCAAAG--AAAGAA-
Selaginop   CCTTGACCAGCTAAATAGTT ACGGCAATTTTC-GAATTAGC GCTC------------ACTTC TTAGAGGGGACTAATCG-TTT C--AAAGCGATGGAAGTTTG
Beroe       CCTTAACCTGCTAAATAGTG ACACGGTTAAGTG-GAATCGGG GTTC------------ACTTC TTAGAGGGGACTAATTG-GTGT TT--AACCAAAG-AAAGAA-
Scypha      CCTTAACCTGCTAAATAGTG ACGGCCGTTCCC-GAATCGCG GCC-------------AACTTC TTAGAGGGGACTAATTG-GTGT TT--AACCGGCGGAAGTTTG
Tetilla     CCTTAACCTGCTAACTAGTA ACGGGAATTCTT-GAATCGTG GTT-------------AACTTC TTAGAGGGGACTATTG-GTGT TT--AACCAAAGTCAGG--A
Tripedali   CCTTAACCTGCTAAATAGTT ACGGGATTCTT-GAATCGGTG CCG-------------ACTTC TTAGAGGGGACAACCGGCCCCG ----AAGCCGGCGGAAGTCTG
Trichopla   CCCTATCCTACTAAATAGTT ACGTGTTCTAC-GGAACACG CG--------------AACTTC TTAGAGGGACAAATTG-GCGT TT--AGCCAAAGTAAGT--A
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Anemonia G AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTGGGCCGGAAAGGTCTGG
Anthopleu  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGG-C CGGACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTGCGGCCGGAAAGGTCTGG
Anemone1   AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GAGGTCAACGAGTCTCT--- -CCTTCGCCGATAGGCGTGG
Lepidisis  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTCGCGGAAGGCACGG
Acanthogo  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGGCAACGAGTCTGGCT- -CCTTCACCGATAGGGTGTGG
Bellonell  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCCTGGGC CGCACGCGCGCTACACTGAC GATGGCAACGAGTCGGCT- -CCTTCACCGAAAGGTNTGG
Protoptil  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCCTGGGC CGCACGCGCGCTACACTGAC GATGGCAACGAGTCGGCT- -CCTTCACCGAAAGGTGTGG
N_bowersi  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCCTGGGC CGCACGCGCGCTACACTGAC GATGGCAACGAGTCCCCT- -CCTTCACCGAAAGGTGTGG
Stichopat  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCCTGGGC CGCACGCGCGCTACACTGAC TATGGCAACGAGTTGGCT- -CCTTCACCGAGAGGTGTGG
Hormathii  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCCACACANGAC GATGTCAACGAGTCTCT--- -CCTTCGCCGATAGGGTGG
Ceratotro  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTCACCGAGAGGTGTGG
Phyllangi  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAAGGAGTTGCT-- -CCTTCACCGAGAGGGTGG
Cerianthu  AGGCGATAACAAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GGCCTCACGCAGCCGGGT- -CCTTTGCCGGAAGGCACGG
Parazoant  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAT GACATCAACGAGTCTCT--- -CCTTCACCGATAGGGTGG
Cerianthe  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAGGGAGTGTCT--- -CCTTCACCGAGAGGGTGG
Enallopsa  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAT GGTCTCACGGAGTGTCT--- -CCTTGGGCCGTTAGGCCCGG
Ceriianthe AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAGAGAGTGTCT--- -CCTTCACCGAGAGGGTGG
Zoanthid1  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC AGCATCAACGAGTCTGT--- -CCTTCACCGATAGGGTGG
Corynacti  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTCACCGAGAGGGTGG
Dactylant  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTGTCT--- -CCTTGGGCCGGAAAGTCTGG
Haloclava  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTTGCT-- -CCTTCGCCGAGAGGGTGG
Acanthopt  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTCACCGAAAGGGTGG
Metridium  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAAAGAGTGTATCT- -CCTTCACCGAGAGGGTGG
Fungia     AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GACGTCAACGAGTGTCTCT- -CCTTCGCCGAAAGCGCGG
Bathypath  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTCACCGAGAGGGTGG
Tajaroa    AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGGCAACGAGTCGGCT- -CCTTCACCGAGAGGGTGG
Tubipora   AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCGGCT- -CCTTCACCGAGAGGGTGG
Pavona     AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTGTATCT- -CCTTCACCGAGAGGGTGG
Stomphia   AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GACGTCAACGAGTGTCTCT- -CCTTCGCCGAAAGCGCGG
Discosoma  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAAAGAGTGTCT--- -CCTTCACCGAGAGGGTGG
Palythoa   AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAT GAGGTCAACGAGTCTCT--- -CCTTCACCGAGAGGGTGG
Antipathe  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAT GATGTCAACGAGTCTCT--- -CCTTCACCGAGAGGGTGG
Cirripath  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTCTCT--- -CCTTCACCGGTTAGGGTGG
AntipatcE  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAACGAGTGTCTCT- -CCTTCACCGATAGGGTGG
EpiactisG  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GAGGTCAACGAGTATCT--- -CCTTCACCGAGAGGGTGG
Flosmaris  AGGCAATAGCAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GAGGTCAACGAGTGTGT--- -CCTTCACCGAATGGCGTGG
Rhizopsam  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCTGGGC CGCACGCGCGCTACACTGTC GATGTCAGAGAGTATCT-- -CCTTCACCGAGAGGGTGG
Tubastrae  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAGAGAGTGTCT--- -CCTTCACCGAGAGGGTGG
Umbellula  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCCTGGGC CGCGCGCGCGCTACACTGAC GATGGCAGGGGAGTTGCT- -CCTTCACCGAGAGGGTGG
Renilla    AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGCTACACTGAC GATGTCAGAGAGTGTCT--- -CCTTCATCGAAAGGTGTGG
Briareum   AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CACACGCGCGTTACACTGGT GATGGCAGGGAGTCGGCT- -CCTTCACCGAAAGGTGTGG
Dendro2    AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTCCTGGGC CGCACGCGCGTTACACTGAC GATGGCAACGAGTCGGCT- -CCTTCGCCGAAAGGTGTGG
Mnemiopsi  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CACGCCCGT--TACACTGAT GAAGCCAGGAGTAICCATT -CCCTGACCGGAAAGGTCGG
Selaginop  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGGCGTTACACTGAT GAATACACGGAGTATCCATT CCCTTCACCGAAAGGTCTGG
Beroe      AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CACGGCCGT--TACACTGAT GAAGCCAGGGAGTATAICG- -CCTTCACCGAATAGGTGTGG
Scypha     AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CGCACGCGCGTTACACTGAT GATGGCAACGAGTCGCT-- -CCTTCGCCGGAAGGTGTGG
Tetilla    AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CACGCCGT--TACACTGAT GAAGCCAGGGAGTCTGA-- -CCTTCACCGAAAGGTGTGG
Tripedali  AGGCAATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC CACGCGCGCGCTACACTGAC GAATGGTAGGCGAGTCATG- -TCTTCGCCGATAGGTGTGG
Trichopla  GGGCCATAACAGGTCTGTGTGA TGCCCTTAGATGTTCTGGGC GACGCGCGGC--TACACTGAT GAAGGCAGAGAGTCC---- TGCTACACTGGGGAGGTGCGG
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Taxon					
AnemoniaG	GTAATCTTCTCAAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Anthopleu	GTAATCTTGTGAAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Anemone1	GTAATCTTGTGAAACGTCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Lepidisis	GTAATCTTCTGAAATCATCGT	CGTGCTGGGGGATAGATCATT	GTAATTCTTGATCNTTGAACG	AGGAATTCCTAGTAAGCACG	AGTCATCAGCTCGCGTTGAT
Acanthogo	GTAATCTTGTGAAATCATCGT	CGTGCTGGGGGATAGATCATT	GTAATTCTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Acanthogo	GTAATCTTGTGAAATCATCGT	CGTGCTGGGGGATAGATCATT	GTAATTCTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Bellonell	GTAATCTTGTGAAATCATCGT	CGTGCTGGGGGATAGATCATT	GTAATTCTTGANCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Protoptil	GTAATCTTCTGAATCATCGT	CGTGCTGGGGGATAGATCATT	GTAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
N_bowersi	GTAATCTTCTGAATCATAGT	CGTGCTGGGGAATAGATCGTT	GTAATTTATCGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAA
Stichopat	GTAATCTTGTGAAAATGTCGT	CGTGGATGGGGGATAGTCGTT	GCAATTCTCGACCTTGAACG	AGGAATTCCTTGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Hormathii	GTAATCTTGTGAAAATGTCAT	CGTGCTGGGGGATAGATCATT	GTAATTATTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Ceratotro	GTAATCTTGT-AAACATGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Phyllangi	GTAATCTTCTGAAAAATGTCAT	CGTGCTGGGGGATAGTCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Cerianthu	GTAATCTTGC--AAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Cerianthu	GAAAACTTCTGAAAATGTCGT	CGTGAATGGGGATAGTCGTT	GCAATTCTCGACCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Parazoant	GTAATCTTTGTGAAAATGTCAT	CGTGCTGGGGAATAGATCGTT	GTAATTATTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Enallopsa	GTAATCTTT-GAAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTATTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Cerianthe	GTAATCTTCTGAAAATATCAT	CGTGCTGGGGGATAGGTCATT	GCAATTCTTGACCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Zoanthidl	GTAATCTTGTGAAANGTCAT	CGTGCTGGGGGATAGATCATT	GTAATTATTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Corynacti	GTAATCTTGT--AAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Dactylant	GTAATCTTGT--AAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Haloclava	GTAATCTTCTGAAAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Acanthopt	GTAATCTTGTGAAATCGTCGT	GTGCTGGGGGATAGGCCGTT	GTAATTTCGGCCCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Metridium	GTAATCTTTGAAAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Fungia	GTAATCTTGT--AAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Bathypath	GTAATCTTGTGAAAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTATGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Talaroa	GTAATCTTGTGAAATCATCGT	CGTGCTGGGGGATAGATCATT	GTAATTCTTGATCTTGAACG	AAAAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Tubipora	GTAATCTTGTGAANCATCGT	CGTGCTGGGGGATAGATCATT	GTAATTCTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Pavona	GTAATCTTCT--AAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Stomphia	GTAATCTTGTGAAATCATCGT	CGTGCTGGGGGATAGGTCGTT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Discosoma	GTAATCTTTC-AAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTGTTGATCTTGAACG	AGGAATTCCTAGTATAGCGCG	AGTCACCAGCTCGCGTTGAT
Palythoa	GTAATCTTGTTAAACGTCAT	CGTGCTGGGGGATAGATCATT	GTAATTATTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Antipathe	GTAATCTTGTGAAACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Cirripath	GTAATCTTGTGANACATCGT	CGTGCTGGGGGATAGATCATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
AntipatGE	GTAATCTTGTGAAACATCGT	CGTGCTGGGGGATAGAGCANT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
EpiactisG	GTAATCTTT-GAAACATCGT	CGTGCTGGGGGATAGATTATT	GCAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Flosmaris	GTAATCTTTTGAAACGTCGT	CGTGCTGGGGGATAGATTATT	GCAATTCTCGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Rhizopsam	GTAATCTTGT-AAACATCGC	CGTGCTGGGGGATAGAATATT	GCAATTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Tubastrae	GGGATCTTTT-AAACATCGT	CGTGATGGGGAATAGATCATT	GTAATGTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Umbellula	GTAATCTTTCAATCATCGT	CGTGATGGGGAATAGATCATT	GTAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Renilla	GTAATCTTTGAATCATCGT	CGTGCTGGGGAAATAGATCATT	GTAATTTTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTGCGTTGAT
Dendro2	GTAATCTTCGGAATCATCGT	CGTGATGGGGATAGATCATT	GCAATTTATTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTTCGGTTGAT
Briareum	GTAATCTTCTGAATCATCGT	CGTGCTGGGGATAGATCATT	GTAATTCTTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCATCAGCTCGCGTTGAT
Mnemiopsi	GTAATCTTGTGAAAACTTCAT	CGTGACAGGGATTGAATCATT	GCAATTATTGGTCTTGAACG	AGGAATTCCTAGTAAAGCACG	AGTCATCAACTGTGCTTGAT
Selaginop	GTAATCTTGTGAAAGTTCAT	CGTGCTGGGGGATAGACCATT	GCAATTATTGGTCTTCAACG	AGGAATTCCTAGTAACACG	AGTCATCAACTCTCGCTTGAT
Beroe	GTAATCTTGTGAAACTTTAT	CGTGCTGGGGATAGACCCTT	GCAATTATTGGTCTTGAACG	AGGAATTCCTAGTAGGCGCA	AGTCATCAACTGTGCGTGAT
Scypha	GTAATCTTGTGAAACTTCAT	CGTGCTGGGGAATAGACCATT	GCAATTCTCGATCTTCAACG	AGGAATTCCTAGTAAGCGCG	AGTCAGCAGCTCGCGTTGAT
Tetilla	GGAATCTTGTGAAACTCCGT	CGTGCTGGGGGAATACATCATT	GCAATTATTGATCTTGAACG	AGGAATTCCTAGTAAGCGCG	AGTCAGCAGCTCGCGTTGAT
Tripedali	GTAATCTTTTGAAAACATCGT	CGTGGATGGGGATAGATCATT	GCAATTATTGATCTTGAACG	AGGAATTCCTAGTAAGGCGCG	AGTCATCAGCTCGCGTTGAT
Trichopla	CTAATCTTT-CAAACTTCAT	CGTGCTGGGGATAGACCCCT	GTAATTATTGGTCTTGAACG	AGGAATTCCTAGTAAGGCGG	AGTCATCAGCTCGCGTTGAT

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Anemoniag   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCCTTGAATTGGGCGGCCG-C  -GCCCCGGCCCACGGAGGCA--
Anthopleu   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCCTTGAATTGGGCGGCCG-C  -GCCCCGGCCCAACGGAGGCA--
Anemonel    TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCCTTGAATTGGGCGGCCG-C  CGCCCCCGGCCAACGGAGGCA--
Lepidisis   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCTGAATTGGGC-ACTGT  CGGAGTCCGCAA-GGTTCT--
Acanthogo   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCTGAATTGGGC-ACTGT  CGGAGTCCGCAA-GGTTCT--
Acanthogo   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCTGAATTGGGC-ACTGT  CAGATGGGCTCCGGTTCATC
Bellonell   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCCGGATTGGGC-ACTGT  CAGATGGGCTCCGGTTCATC
Protoptil   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCCGGATCGGCGGC-TGT  CGGATTCGCAA--GACTCG-
N_bowersi   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTCCTTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGGATTGGGCGGCCG-T  CGGAGTTGTAA--GACTCT-
Stichopat   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGGATTGGGCGGCCG-C  CGCCCCGGCCAACGGAGTA--
Hormathii   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCCTGAATTGGGCGGCCG-C  CGCCCCCGGCCAACGGAGGCA--
Ceratocro   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCCTGAACTGGGCGGCCGCA  TACTCTGTCTTCGTACGGAG
Phyllangi   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGAACTGGGCGGCCG-A  TGCTCTGGCGGACAGAGC--
Cerianthu   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGATCGAAATGGTTTAGTGAG  GCCTCCCGATGGGGCGGCCG-C  C--TCCTTCAAAGGAAA---
Parazoant   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCTGAATTGGCGGCCG-C  -GCCCCGGCAACGGA--
Enallopsa   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTCGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGGATTGGGCGGCCG-A  TACTCTGGCAACAGAGC--
Cerianthe   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTCCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCCGATCCCGGCCG-C  C--TCAGGCCTCGTTGC--
Zoanthidi   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGGATCGGGCGGCCG-C  CGGGCCGGCAAGGAGGCA--
Corynacti   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGAATTGAACGGCCG-A  TATTCTGGCAACAGAGC--
Dactylant   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCTGATTGGGCGGCCG-C  CACCCCGGCAACGGAGGCA--
Haloclava   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCCCGAATTGGCGGCCG-C  CGCCCCGGGTCACGGAGGCA--
Dactylant   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GATTCTGGAATCGGC-ACTGT  CGGATTCGGCAA-GTGTCT-
Acanthopt   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCTGATTGGGCGGCCG-C  CGCCCCGGCCAACGGAGGCA--
Metridium   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCTGAATTGGGCGGCG-A  TGCTCTGGCAACAGAGC--
Fungia      TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCTGAATTGGGCGGCG-C  CGCCCAGCAACGGAGGTA--
Bathypath   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCCGGAATTGGC--ACTGT  CAGATGGGCGCTTCGGTTCATC
Taiaroa     TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTCGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCGGATTGGGC--ACTGG  TAGACGGGCTTCGGTTCGTC
Tubipora    TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCRGAATTGGC-ACTGT  TACTCTGGCAACAGAGC--
Pavona      TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACCAC  CGAATTGAAATGGTTTAGTGAG  GACTCCCGATTGGGCGGCG-A  CGCGCCGCGCGACGGAGCA--
Stomphia    TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGGG  GCCTCCTGACTGGGCGGCCG-G  CGCTCTGGGCGGACAGAGGGTT
Discosoma   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGTTTTAGTGAG  GCCTTCCGATTGGGCGGCG-C  CGCT-TCGTTTTCGTGGCA-
Palythoa    TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCCGATTGGGCGGCG-C  CGCCCCGGCAACGGAGTA--
Antipathe   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCCGATTGGGCGGCG-C  CGCCCCGGCAACGGAGTA--
Cirripath   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTCCTGATTGGGCGGCG-C  CGCCCCGGCAACGGAGTA--
AntipatGE   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCTTACTTGGGCGGCG-C  CGCCCCGGCAACGGAGTA--
EpiactisG   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCTTACTGTCGCGCG-C  TATTCTGGCAACAGAGC--
Plosmaris   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GACTCTTATTGGCGGCG-C  CGCCCCGACCGAACGGAGTA--
Rhizopsam   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCTTACTGGCGGCG-A  TGCTCTGGCAACAGCGC--
Tubastrae   TACGTGCCGTGCCCTTTGTAC  ACACCGCCCGTCGCTACTAAT  CGAATTGAAATGGTTTAGTGAG  GGCTTCTGACTGTCGCCG-C  TAC-CTGGCAACAGAGC--
Umbellula   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGGATCGGGCGGCTCC-GT  CGTGTTCGAAAGAAATCT--
Renilla     TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTATAGTGAG  GACTCCGGATCGGGCGG-TGT  CGGATTCGTAA--GACTCT-
Dendro2     TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGGATTTGTACTGT  CGGGTTCGAAA--GAGCCT-
Briareum    TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GCCTTCGGATCGGCGTGTC  GGATTCGGCAAGACTCT--
Mnemiopsi   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTCGCTACTAC  CGAATTGAAATGGTTTAGTGAG  ATCTCGGGGATTGGGCGACGCC  ATGCY-GCG-AGG------
Selaginop   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTCGCTACTAC  CGAATTGAAATGGTTTAGTGAG  ATCTCGGGGATTGGCGTG-CC  TGGTTACCTTCACG-----G
Beroe       TACGTCCCTGCCCTTTGTAC  ACACGCCC-GTGCGTACTAC  CGAATTGAAATGGTTTAGTGAG  ATCTCGGGGATTGCCGATG-CC  GTGCC-GCAAGGAAT----G
Scypha      TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTGCTACTAC  CGAATTGAAATGGTTTAGTGAG  ATCTTCGGATTGCTGGCTCG  GCGGCCTTGTGCTGCC--
Tetilla     TACGTCCCTGCCCTTTGTAC  ACACGCCCGTCGGCTACTAC  CGAATTGAAATGGTTTTGTGAG  ATCTTCGGGATTGGACGGCCG  TGGCAGGCGACT------
Tripedali   TACGTCCCTGCCCTTTGTAC  ACACCGCCCGTCGCTACTAC  CGAATTGAAATGGTTTAGTGAG  GAATCCGGATTGGCAGCCCT  CTGGTGCGGCAACG------
Trichopla   TACGTCCCTGCCCTTTGTAC  ACACCGCCC-T-GCTACTAC  CGAATTGGAATGGTTTAGTGADGGC  GTCACTTTTACGGTT------
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AnemoniaG  ----G-CGGAC-TGCCGAGA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Anthopleu  ----G-CGGAA-TGCCGAAA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Anemonel   ----G-CGGAC-TACCGAAA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Lepidisis  ----GACGGAGGT-CCAACA  AGTTGGTTCAA-ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Acanthogo  C---GACGGACGT-C-AAAA  AGTTGGGTCAA-ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Bellonell  C---GACGGACGT-C-AAAA  AGTTGGGTCAA-ACTTGATCG  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Protoptil  ----GACGGA-G-GCCGAGA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
N_bowersi  ----GACGGAAG-CTTGAAA  AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Stichopat  ----G-CGGA--TGCCGAGA  AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Hormathii  ----G-CGGAC-TGCCGAAA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Ceratotro  -GGGGCCGGATTTGCCGGAA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Phyllangi  ----GCCGGA--TGCCGGAA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Cerianthu  ----GC-GGACCGTCCGAAA  AGTCGGGTCAA-ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Parazoant  ----GCCAGCGGATGTCGAAA AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Enallopsa  ----GCC--GGATGCCGGGA  AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Cerianthe  --CCGGCATGCGTCGGAGA   AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Zoanthidl  ----GC-GGA--TGTCGAAA  AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Corynacti  --GTCGGA--TGTTGGGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Dactylant  ----GC-GGAC-TGCCGAGA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Haloclava  ----GC-GGAC-TGCCGAGA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Acanthopt  ----GACGGAC--GCCGAGA  AGCTAATTCGA-ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAG-TG  AACCTGC
Metridium  ----GC-GGAC-TGCCGAAA  AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Fungia     --GCCGGA--TGCCGAGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Bathypath  --GC-GGA--TGCCGAGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Taiaroa    C---GACGGAC--GTCAAAA  AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Tubipora   C---GCCGGAC--GTCAAAA  AGTTGGGTCAA-ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Pavona     --GCCGGAT--GCCGGAA    AGTTGGGTCAA-ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Stomphia   --GC-GGA-CCGCCGACA    AGTTGTTCGA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Discosoma  --GGAT--GCCGGGA       AGTTGTTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Palythoa   --GC-GGACTTGTCGAAA    AGTTGGTCAA--ACTTGAGCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Antipathe  --GC-GGAT--GCCGAGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Cirripath  --GC-GGAT--GCCGAGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
AntipatGE  --GC-GGAT--GCCGAGA    AGTTGGGTTAA-AATTGAATA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
EpiactisG  --GGTGGAC-TGCCGGGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AAC-TGC
Flosmaris  --GC-GGA--TGCCGAGA    AGTTGGGTTAA-AATTGATTA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AAC-TGC
Rhizopsam  --GCCGGA--TGCCGGAA    AGTTGGTGCAAACTTGATCA   TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AAC-TGC
Tubastrae  --GGGGGATT-TCGGGA     AGTTGGGGGAAG-CTTGAGTA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AAC-TGC
Umbellula  --GACGGA--CGCCGAAA    AGCTGGGTCAA-ACTTGCTCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Renilla    --GACGGAAG--GCCGAGA   AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Dendro2    --GACGG--CCGCCGAGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Briareum   --GACGGAGGTC--GAGA    AGTTGGTCAA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Mnemiopsi  ---CACGCGCGCCGCGAGA   ACTTGCTCGA--ACTTGATCA  TCTAGAGGAGAGTAAAAGTCG TAACAAGGTTTCCGTAGGTG  AACCTGC
Selaginop  GTCCAACGGTTTACCGAGA   AGCTGCTCGA--ACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AAC-TGC
Beroe      GTGCCGCC--------GAGA  ACTTGCTCAA--ACATG----  ------------------    ------------------    -------
Scypha     -GGGCATAGG-GAAA       AGTTGCTCAA--ACTT-----  ------------------    ------------------    -------
Tetilla    -GCCGCGGCCGATTCGAGA   AGTCGGATCAA-ACTTGATCA  TTTAGAGGAAGT--------  ------------------    -------
Tripedali  --GCCTATGGGGTTACCGAGA AGCTTTTCAA-ACCGATCA    TTTAGAGGAAGTAAAAGTCG  TAACAAGGTTTCCGTAGGTG  AACCTGC
Trichopla  GTGCCAATTATC----GAGA  AGTTGATCAA-ACTTGATCA   TCTAGAGGAGAGTAAAAGTCG TAACAAGGTTTCCGTAGGTG  AACCTGC
;
end;
```

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Appendix 2

Appendix 2 **Full alignment of 18S rDNA sequences for Chapter 4, shown in NEXUS format for PAUP*. Positions removed for analyses:**
189-197, 253, 372, 472-474, 501-502, 509, 597, 762-767, 813, 830-833, 839, 1039, 1362-1380, 1524, 1680-1737, 1756-1805.

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[Name: Narellanut       Len: 1805    Check: 4B00ECB5]
[Name: Lepidisis        Len: 1805    Check: AA2D1174]
[Name: Orstomisis       Len: 1805    Check: BE35E131]
[Name: Umbellula        Len: 1805    Check: 57D787A4]
[Name: Paramuriceid     Len: 1805    Check: 5454CE07]
[Name: Acanthogorgia    Len: 1805    Check: ED14DDA7]
[Name: Taiaroa          Len: 1805    Check: E4969E50]
[Name: BellonellaGEN    Len: 1805    Check: CB98DF4F]
[Name: Protoptilum      Len: 1805    Check: 72883BA9]
[Name: Anthomastus      Len: 1805    Check: 4BB42A3A]
[Name: Narellabow       Len: 1805    Check: 82D412B3]
[Name: Protodendron     Len: 1805    Check: 73C4A2B]
[Name: Tubipora         Len: 1805    Check: 72ACD036]
[Name: Paragorgia       Len: 1805    Check: 5B1F70C8]
[Name: Lophogorgia      Len: 1805    Check: 7F7912C9]
[Name: Chrysogorgia     Len: 1805    Check: 72C0BC2E]
[Name: Acanthoptilum    Len: 1805    Check: 177FF559]
[Name: Clavularia       Len: 1805    Check: F2EA24EE]
[Name: CoralliumCR2     Len: 1805    Check: 58547539]
[Name: Renilla          Len: 1805    Check: 289A5E96]
[Name: Stylatula        Len: 1805    Check: D4FECB7B]
[Name: Virgularia       Len: 1805    Check: EC7387FB]
[Name: LeioptilusGEN    Len: 1805    Check: 6C06D191]
[Name: AlcyoniumGEN     Len: 1805    Check: 1B9F806F]
[Name: C_kisch1         Len: 1805    Check: A5A0DE58]
[Name: Lemnalia         Len: 1805    Check: FF4B1823]
[Name: Xenia            Len: 1805    Check: 8D567117]
[Name: Calicogorgia     Len: 1805    Check: E1682F6C]
[Name: EuplexauraGEN    Len: 1805    Check: 6AB1783C]
[Name: Anthoptilum      Len: 1805    Check: C0B06062]
[Name: Eunicea          Len: 1805    Check: 6D6AE5C4]
[Name: Anthothela       Len: 1805    Check: C6EB7B6C]
[Name: Telestula        Len: 1805    Check: DE4ED1CC]
[Name: Briareum         Len: 1805    Check: 61061037]
[Name: Siphonogorg      Len: 1805    Check: DDF5A19A]
[Name: Melitella        Len: 1805    Check: FF94E4FD]
[Name: Calicgorgia      Len: 1805    Check: 17378IA1]
[Name: Juncee2          Len: 1805    Check: 44D4F6EC]
[Name: Coelogorgia      Len: 1805    Check: 12EC02B1]
[Name: Erythropodium    Len: 1805    Check: 94368F93]
[Name: JunceellaT       Len: 1805    Check: EBD04DD4]
[Name: Hellop2          Len: 1805    Check: 676F6ED1]
[Name: Plumigorgia      Len: 1805    Check: B9614BC4]
[Name: Dendro2          Len: 1805    Check: 73397351]
[Name: Selaginopsis     Len: 1805    Check: A6556CC1]
[Name: Berce            Len: 1805    Check: 7B883AE0]
[Name: Mnemiopsis       Len: 1805    Check: EB18375E]
[Name: Scypha           Len: 1805    Check: B15909 3F]
[Name: Tripedalia       Len: 1805    Check: 2E3B3361]
[Name: Trichoplax       Len: 1805    Check: 3EB4E51F]
[Name: Tetilla          Len: 1805    Check: 33E53401]
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    dimensions ntax=53 nchar=1805;
    format datatype=dna interleave missing=X gap=-;
    matrix

AnemoniaG   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACG-TA   C--TACTTGGATAAACCGTGGT
Hormathii   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACC-TA   C--TACTTGGATAAACCGTGGT
Narellanu   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACC-TA   C--TACTTGGATAAACCGTAGT
Lepidisis   CCAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACCATA   C--TACATGGATAAACCGTAGT
Orstomisi   CCAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACCATG   C--TACATGGATAAACTGTAGT
Umbellula   CTAAGTACGAG--CACTT--   TGCTCATGAAAACTGCGAAT   TGCTCATTAAATCAGTTAACC   ATTTATTTGATTGTATGTAC--TA   C--TACATGGATAAACCGTAGT
Paramuric   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Acanthogo   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Tairoa      CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Bellonell   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Protoptil   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACC-TA   C--TACTTGGATAAACCGTAGC
Anthomast   CTAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTAC--TG   C--TACTTGGATAAACCGTAGT
Narellabo   CTAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACC-TA   C--TACATGGATAAACCGTAGT
Protodend   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Tubipora    CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGC
Paragorgi   CTAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACC-TG   C--TACTTGGATAAACCGTAGT
Lophogorg   CTAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Chrysogor   CTAGGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACC-TA   C--TACTTGGATAAACCGTAGT
Acanthopt   CTAAGTATGAG--CACTC--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Clavulari   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Corallium   CTAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGC
Lemnalia    CTAAGTACGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   ATTTATTTGATTGTATGTACTATA   C--TACTTGGATAAACCGTAGT
Xenia       CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   ATTTATTTGATTGTATGTACTATA   C--TACTTGGATAAACCGTAGT
Calicogor   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Euplexaur   CTAAGTATANT--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACATTT   C--TATTTGATAAACCGTAGT
Anthoptil   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTAACCTA   C--TACTTGGATAAACCGTAGT
Eunicea     CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGTAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Anthothel   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Telestula   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   ATTTATTTGATTGTTGTACTATA   C--TACTTGGATAAACCGTAGT
Briareum    GTAAGTATAAG--CACTCTT   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACCTTA   C--TACTTGGATAAACCGTAGT
Siphonogo   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Melitella   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACTCTA   C--TACTTGGATAAACCGTAGT
Calcigorg   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACACTA   C--TACTTGGATAAACCGTAGT
Juncee2     CTAAGTATGAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTTGTACCTTA   C--TACTTGGATAAACCGTAGT
Coelogorg   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   ATTTATTTGATTGTACTCTA     C--TACTTGGATAAACCGTAGT
Erythropo   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACCCTA   C--TACTTGGATAAACCGTAGT
Junceella   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACCCTA   C--TACTTGGATAAACCGTAGT
Heliop2     CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTATGTACCTA    C--TACTTGGATAAACCGTAGT
Plumigorg   XXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXXXX
Dendro2     CTAAGTACGAGA-CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATT   GTTTATTTGATTGTATGTACTTG    C--TACTTGGATAAACCGTAGC
Selaginop   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATT   GTTTACTTGATTATGTGCACT-     CTTACACTGGATANCTGTGGT
Beroe       CTAAGTATAAA--CTTTT--   ATACGGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTCTACTTGATTGTGCCCTA       C--TACATCGATAAACCGTAGT
Mnemiopsi   CTAAGTATAAA--CTTTT--   ATACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATTGTGGCCTA       C--TACTTGGATAACCGTAGT
Scypha      CTAAGTATAAG--CTTTT--   ATACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTCTATTTGATTGTGCCCTA       C--TACTTGGATAACCGTAGT
Tripedali   CTAAGTATAAGCGTTCTT--   ATACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTACTGATCGTGTGACTTA      CTTACACTGGATAACTGTGGT
Trichopla   CTAAGTATAAG--CACTT--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATC   GTTTATTTGATCGTGTA----TC    C--TACACTGGATAACTGTGGT
Tetilla     CTAAGTATGAA--CGCTC--   GTACTGTG-AAACTGCGAAT   GGCTCATTAAATCAGTTAATA   GTTTATTTGATGGTGCT-TG       C--TACACTGGATAAACTGTGGT
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Hormathii   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTCAAAAACCAATGCGGGTT  C-TGCCCGGGTTCT----TTG
Narellanu   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTCAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Lepidisis   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTCAAAAACCAATGCGGGTT  CGCGGCCGGGTCAT----TTG
Orstomisi   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTCAAAAACCAATGCGGGTT  CACGGCCGGGTACC----TTG
Umbellula   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTCAAAAACCAATGCGGGTT  CACGGCCGG--ACTACATTTG
Paramuric   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
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Talaroa     AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Bellonell   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  AACGGCCGCCTTACCCACTTG
Protoptil   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  GTTAAAAAGCCAATGCGGGTT  CACGCGCCGGGTTCT---TTG
Anthomast   AATTCTAGAGCTAATACATG  CTG-AAAGTCCCGACTCTCT-  GGAAGGGACGCATTTAATTAG  ATTCAAAAACTAATGCAGGTT  TGCGCCGGCCTTCG----TTG
Narellabo   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTCAAAAACCAATGCGGGTT  CGCGGCCGGGTCAT----TTG
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Tubipora    AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTTT   GGAAGGGATGCATTGAATTAG  ATTCAAAAACCAATGCGGGTT  CGCGGGCGGCTTACCCACTTG
Paragorgi   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTACT-   GGAAGGGATGTATTTAATTAG  ATTCACGCCAAAATGCAGGTT  TAGGCCTGGTTTG-----TTG
Lophogorg   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTCAATTAG  ATTAAAAAACCAATGCGGGTT  AACGGCCGCCTTACCCACTTG
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Clavulari   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGCATTGAATTAG  ATTTAAAAACCAATGCGGGTT  CAAGCGCGGGCGTT----TTG
Corallium   AATTCTAGAGCTAATACATG  CTA-AAAGTCCCGACTACT-   GGAAGGGATGCATTGAATTAG  ATTTAAAAACCGATGCGGGTT  TTCGCCTGGTTTG-----TTG
Renilla     AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTTAAAAACCGATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Stylatula   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTTAAAATACCAATGCGGGTT TAAGTCCGGTTTCT----TTG
Virgulari   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAATACCAATGCGGGTT  CACGGCCGGGTTCT----TTG
Leioptilu   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTC--   GGAAGGGATGTATTTAATTAG  ATTTAAAATACCAATGCGGCAA TA-GCCCGGTCTT-----TTG
Alcyonium   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTTAAAAAACCAATGCG-CTT CGCGGCCGCCTTACCCACTTG
C_kischl    AATTCTAGAGCTAATACATG  CTA-AAAGTCCCGACTACT-   GGAAGGGATGCATTGAATTAG  ATTTAAAAACCGATGCAGGTG  TTCGCCTGGTTTG-----TTG
Lemnalia    AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTTAAAAAACCAATGCGGGTT CACGGCCGCCTTACCCACTTG
Xenia       AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTTTG   GGAAGGGATGTATTTAATTAG  ATTTAAAAAACCAATGCGGGTT AACGGCCGCCTTACCCACTTG
Calicogor   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Euplexaur   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCTG   GGAAGGGATGTATTTAATTAG  GTTAAAAAGCCAATACCGGGTT CACGGCCGGGTTCT----TTG
Anthoptil   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTCT-   GGAAGGGATGTATTTAATTAG  ATTTAAAAAACCAATGCGGGTT CACGGCCGGGATTT----TTG
Eunicea     AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCG-CTT  CGCGGCCGCCTTCT-CACTTG
Anthothel   AATTTTAGAGCTAATATATG  CGA-AAAGTCCCGACTTTCT   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Telestula   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCGTATT----TTG
Briareum    AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTTCT   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  AACGGCCGCGGTG-----TTG
Siphonogo   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTTAAAAAACCAATGCGGGTT AACGGCCGCCTTACCCACTTG
Melitella   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Calcigorg   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Juncee2     AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTGC-   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTT-----TTG
Coelogorg   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTTTG   GGAAGGGATGTATTTTTATTAG ATTAAAAAACCAATGCGTCTT  CACGGCGCCTCAACCAATTG
Erythropo   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTT-   GGAAGGGATGTATTTTTATTAG ATTAAAAAACCAATGCGGGTT  CACGGCGCCGGTCTC----TTG
Junceella   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTC-   GGAAGGGATGTATTTAATTAG  ATTAAAAAACCAATGCGGGTT  CGCGGCCGCCTTACCCACTTG
Heliop2     AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTCG   GGAAGGGATGTATTTAATTAG  ATTTAAAAAACCAATGCGGGTT CGCGGCCGCTTACCCACTTG
Plumigorg   XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX
Dendro2     AATTCTAGAGCTAATACATG  CGA-AAAGTCCCAACTTTAC   GGAAGGGATGCATTGAATTAG  ATTTAAAAACCAATGCGGGTT  TACGGCTTGGCTCTTTG-TTG
Selaginop   AATTCTAGAGCTAATACATG  CGA-AATCTCCCAACTTTAC   GGAAGGGATGTATTTAATTAG  ATTTAAAAAACCAATGCGGGTT TCGGGGCTGCGGCATTA-AAG
Beroe       AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTC--   GGAAGGGATGTATTTAATTAG  AGTTAAAAAACCAATGCGGAGTCT XXXXXXXXXXXXXXXXXXX
Mnemiopsi   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTCTC-   GGAAGGGATGTATTTAATTAG  ATTTAAAAGCCAATGCG-TTT  AACGACGCTT----TTCG
Scypha      AATTCTAGAGCTAATACATG  CGTTAAAGTCCTCGACCTCTC  GGAAGGGATGGATTTTAATTAG ATTAAAAAACCAATACCGGTT  AAAGGCTGG-----TTCTATTG
Tripedali   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACCTCT-   GGAAGGGATGTATTTAATTAG  ATCAAAAAACCAATGCGGGGTT TCGCGCGCCG--TTCTATTG
Trichopla   AATTCTAGAGCTAATACATG  CGA-AAAGTCCCGACTTTCG   GGAAGGGATGTATTTTATTAG  ATCCAAAAACCAGCCGGGGTC  TGCCGGTGT-----TTG
Tetilla     AATTCTAGAGCTAATACATG  C-ACAAGGTCCC-ACTTTT-   GGGAGGGACGTATTTTATTAG  ATCCAAAAACCAGCCGGGCTC  CTCGTGGTCCCGGGTCCCTGG
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AnemoniaG  GTGATTCATTAGTAACTGATC  GAATCGCCATGGCCCTT-----  ---GGGCTGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTGT
Hormathii  GTGATTCATTAATAACTGTTC  GAATCGCCACGGCCCTT-----  ---GCGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAT
Narellanu  GTGATTCATTAGTAACTGTTC  GAATCGCATGGCCCTTT-----  ---GGGCCGGCG-ATGANTGC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Lepidisis  GTGATTCACATAGACTCTGC  GAATCGCCATGGCCCTTT----  ---GGGCCGGCG-ANGTNTGC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Orstomisi  GTGATTCACAATGACTCTGC  GAATCGCCATGGCCTTT-----  ---GGGCCGGCG-ANGTNTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Umbellula  GTGATTCGAATGACTGTGC  CAATCGCCATGGCCTC-----  ----GACCGGGCG-ANGTTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGCAG
Paramuric  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Acanthogo  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Talaroa    GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCTTTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Bellonell  GTGATTCATTAGTAACTGTTC  GAATCGCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Protoptil  GTGATTCATTAATAACTGTTC  GAATCGCCATGGCCTTAT----  ---GGGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Anthomast  GTGATTCATTAATAACTGTGC  GAATCGCCATGGCCTTT-----  ---GGGCCGGCG-ANGTNTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Narellabo  GTGATTCATTAGTAACTATTC  GAATCGCCATGGCCCTC-----  ----CGGTACCGGCG-ANGTTTC  GTTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Protodend  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Tubipora   GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCAACTT  T--GGGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Paragorgi  GTGATTCTTAAATAACTGTTC  GAATCGCATGGCCTTT-----  ---GGGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Lophogorg  GTGATTCATTAGTAACTGTTC  GAATCGCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAGTTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Chrysogor  GTGATTCATTAGTAACTCTC  GAATCGCCATGGCCCTC-----  ---CGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Acanthopt  GTGATTCATTAGTAACTTTTC  GAATCGCAAGGTCCT-----  ---GGTACCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Clavulari  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Corallium  GTGATTCTAAATAACTGTGG  GAATCGCCATGGCCTTT-----  ---GGGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAATGTAG
Renilla    GTGATTCATTAATAACTCTTC  GGATCGCCATGGCCTCAC-----  ---GTGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Stylatula  GTGATTCATTAGTAACTAATTC  GGATCGCCATGGCCATTC-----  ---GTGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Virgulari  GTGATTCATTAGTACATATTC  GAATCGCCATGGCCATA-----  ---CGGCCGGCG-ANGTTTC  ATTCAGTTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Leioptilu  GTGATTCATTAATAACTGTTC  GAATCGCCATGGCCTTTT-----  ---GGGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AATTGTCGAATGGTAAGGTAG
Alcyonium  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
C_kischi   GTGATTCTAAATAACTGTGG  GAATCGCCATGGCCTTT-----  ---GGGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Lemmalia   GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTTAAC  TTTGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Xenia      GTGATTCATTAGTAACTAATTC  GAATCGCCATGGCCTTTTCCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Calicogor  GTGATTCATTAGTAACTGTTC  GAATCGCATGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Euplexaur  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTT-----  ---GTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Anthoptil  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTAT-----  ---GTGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Eunicea    GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCTCTG  TTCGTGCCGGCGG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Anthothel  GTGATTCATTAGTAACTGTTC  GAATCGCCATGGGCCTTCTCTG  TTCGTGCCGCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Telestula  GTGATTCATTAGTAACTGTTC  GAATCGTATGGCCTCA-----  ---CGTGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Briareum   GTGATTCATTAGTAACTTATC  GAATCGCCATGGCCTCT-----  ---CGTGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Siphonogo  GTGATTCATTAGTAACTTTTC  GAATCGCATAGCCTTCTCTG  TTCGTGCCGGCGG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Melitella  GTGATTCATTAGTAACTTTTC  GAATCGCCATGGCCTTCTCTG  TT-GTGCCGGCGG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Calcigorg  GTGATTCATTAGTAACTGTTC  GAATCGCACGGGCTTCTTTG  TTCGTGCCGGCGG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Juncee2    GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTA-----  ---CGTGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Coelogorg  ATGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTCCTT  T--GTGCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AATTGTCGAATGGTAAGGTAG
Erythropo  GTGATTCATTAGTAACTCTTC  GAATCGCATGGCCTTT-----  ---CGTGCCGGACG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Junceella  GTGATTCATTAATAACTCTTC  GAATCGCATGGCCTCA-----  ---CGCCCGGCGG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Heliop2    GTGATTCATTAGTAACTGTTC  GAATCGCCATGGCCTTTA-----  TTCGTGCCGGCGG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Plumigorg  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Dendro2    GTGATTCTAAATAACTGTGG  GAATCGCATGGCCTTT-----  T--GGCCCGGCG-ANGTTTC  ATTCAAATTTCTGCCCTATC  AATTGTCGAATGGTAATGTAG
Selaginop  ATGACTCATTGATAACTTTTC  GAATCGTACGGGCT-----  ---CGTGCCGACG-ATATTTC  TTTCAAATTATCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Beroe      GTGATTCATTAATAACTGTTC  GAATCGCACGGGCCCT-----  ---AGTGCCGGGCG-ANGTTTC  ATTCGAGTTTCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Mnemiopsi  GTGATTCATAATAACTGTTC  GAATCGCCATGGCCCCT-----  ---CGTGCCGGCG-ANGTTTC  ATTCGAGTTTCTGCCCTATC  AACTTTGAATGGTAAGGTAG
Scypha     GTGATTCATGATGAACTGAAC  GGRTCGCACGGGCTCT-----  ---TGCGCCGGGCG-ANGACTC  ATTCAAATTATCTGCCCTATC  AACTGTCGAATGGTAAGGTAG
Tripedali  GTGATTCATGATGAACTTTTC  GAATCGCCATGGCCCCT-----  ---TGTACCGGGCG-ANGACTC  ATTCAAGTTTCTGCCCTATC  AACTTTCGATGGTAAGGTAT
Trichopla  GTGATTCATATAATAACTTATC  GAATCGGCATGGCGGCT-----  ---TGTGCCGGGCG-ANGGTTC  ATTCGAGTTTCTGCCCTATC  AACTTTCGATGGTAAGGTAG
Tetilla    GCGATTCATTATAACTGTTC  GAATCGCACGGGCCT-----  ---TGGGCGGCGGGG-ANGGTCC  ATTCAAATTTCTGCCCTATC  AACTTTCGATGGTAAGGTAG
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Anemonia G  TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Hormathii   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGGAGAGGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Narellanu   CGGCTTACCATGGTTGCAAC  GGGTGACGGANAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Lepidisis   TGGCTTACCATGGTTGCCAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Orstomisi   TGGCTTACCATGGTTNCAAC  GGGTGACGGAGAAATT-AGGG  TTCNATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Umbellula   TGGCTTACCATGGTTGTAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Paramuric   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Acanthogo   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Talaroa     TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Bellonell   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Protoptil   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Anthomast   TGGCTTACCATGGTTGCCAC  GGGTGACGGAGAAT-CAGTG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Narellabo   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAT-CAGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Protodend   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Tubipora    TGGCTTACCATGGTCGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGT  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Paragorgi   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Lophogorg   TGGCCTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Chrysogor   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Acanthopt   TGGCTTACCATGGTCGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Acanthopt   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Clavulari   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Corallium   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAT-CAGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Renilla     TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Stylatula   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAT-CAGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Virgulari   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Leioptilu   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCTTA  TCCAAGGAAGGCAGCAGGCG
Alcyonium   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
C_kischi    TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAT-CAGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Lemnalia    TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAT-CAGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Xenia       TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Calicogor   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Euplexaur   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGGGCTACCACA  TCCAAGGAAGGCAGCAGGCG
Anthoptil   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Eunicea     TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Anthothel   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Telestula   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGGGCTACCACA  TCCAAGGAAGGCAGCAGGCG
Briareum    TGGCTTACCATGGTGGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Siphonogo   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Melitella   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Calcigorg   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Juncee2     TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-GGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Coelogorg   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-GGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAATGGAAGGCAGCAGGCG
Erythropo   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCA
Junceella   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Heliop2     TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Plumigorg   XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Dendro2     TGGCCTACCATGGTTTTTAC  CGGTGACGGAGAAATGCAGGG  TTCGGTTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCCGCAGGCG
Selaginop   TGGCTTACCATGGTTACAAC  GGGTGACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CCGAGAAATGG-CTACCACA  TCTAAGGAAGGCAGCAGGCG
Beroe       TGGCTTACCATGGTTACAAC  GGGTGACGGAGAAATT-AGGG  TTCGTTTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  XXXXXXXXXXXXXXXXXXXX
Mnemiopsi   TGGCTTACCATGGTTACAAC  GGGTAACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAATGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Scypha      TGGCTTACCATGGTTGCAAC  GGGTAACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CCGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Tripedali   TGGCTTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGRG  TTCGATTCCGGAGAGGGAGC  CTGAGAAATGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Trichopla   TGGCTTACCATGGTTACAAC  GGGTAACGGAGAAATT-AGGG  TTCGATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
Tetilla     TGGCCTACCATGGTTGCAAC  GGGTGACGGAGAAATT-AGGG  TTC-ATTCCGGAGAGGGAGC  CTGAGAAACGG-CTACCACA  TCCAAGGAAGGCAGCAGGCG
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AnemoniaG  CGCAAATTACCCAAATCC-TG  ACTCAGGGAGGTAGTGAACAA  GAACTAACAATACAGGGCTT  TTGT-AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Hormathii  CGCAAATTACCCAAATCC-TG  ACTCAGGGAGGTAGTGAACAA  GAAATAACAATACAGGGCTT  TTCT-AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Narellanu  CGCAAATTACCCAAATCC-TG  ACGCAGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Lepidisis  CGCAAATTACCCAAATCC-TG  ACACAGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Orstomisi  CGCAAATTACCCAAATCC-TG  ACACAGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Umbellula  CGTAAATTACCCAAATCC-G   ACACAGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTC  TACG---AGTCTT---GTAA-T  TGGAATGAGTACCAATATAAA
Paramuric  CGCAAATTACCCAAATCC-TG  ACGGTGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAGCTAAA
Acanthogo  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Taiaroa    CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Bellonell  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Protoptil  CGCAAATTACCCAAATCC-G   ACACGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTC  TTCG---AGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Anthomast  CGTAAATTATCCAAATCC-TG  ACACAGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTA---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Narellabo  CGCAAATTACCCAAATCC-TG  ACGCAGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Protodend  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Tubipora   CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Paragorgi  CGTAAATTACCCAAATCC-TG  ACACAGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Lophogorg  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Chrysogor  CGCAAATTACCCAAATCC-TG  ACGCAGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Acanthopt  CGCAAATTACCCAAATCC-G   ACACGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTCG---AGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Clavulari  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Corallium  CGTAAATTACCCAAATCCCTG  ACACAGGGAGGTAGTGAACGA  AAAATAACAATACATGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Renilla    CGCAAATTACCCAAATCC-G   ACACGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTC  TTC---GAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Stylatula  CGCAAATTACCCAAATCC-G   ACGCGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTC  TTC---GAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Virgulari  CGCAAATTACCCAAATCC-G   ACACGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTC  TTC---GAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Leioptilu  CGCAAATTACCTAAATCC-G   ACACGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCCC  CTTC--GAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Alcyonium  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
C.kischl   CGTAAATTACCCAAATCC-TG  ACACAGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Lennalia   CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACGA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Xenia      CGCAAATTACCCAAATCC-TG  ACATGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Calicogor  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Euplexaur  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Anthoptil  CGCAAATTACCCAAATCC-G   ACRCRGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Eunicea    CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
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Briareum   CGCAAATTACCCAAATCC-G   ACACGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TCG---AAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Siphonogo  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTCTAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
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Calcigorg  CGCAAATTACCCAAATCC-TG  ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Juncee2    CGCAAATTACCCAAATCC-G   ACTCGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTG  TTTTGTAAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Coelogorg  CGCAAATTACCCAAATCC-G   ACGTGGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTGTAAGTCTT---GTAAAT  TGGAATGAGTACAACTAAA
Erythropo  CGCAAATTACCCAATCC-TG   ACACAGGGAGGTAGTGAACAA  AAA--TAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAATTTAAA
Junceella  CGCAAATTACCCAAATCC-G   AC-TCGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTC---AAGTCTT---GTAA-T  TGGAATGAGTACAATT-AA-
Heliop2    CGCAAATTACCCAAATCC-TG  ACGTCGGGAGGTAGTGAACAA  AAAATAACAATACAGGGCTT  TTTTCTAGTCTT---GTAA-T  TGGAATGAGTACAATTTAAA
Plumigorg  XXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Dendro2    CGTAAATTACCCAAATCC-TG  ACACAGGGAGGTAGTGAACAA  TAAATAACAATACAGGGCTT  T-AACGAGTCTT---GTAA-T  TGGAATGAGTACAACTAAA
Selaginop  CGGAAATTACCCAAATCC-A   ATTCGGGGAGGTAGTGAACAA  GAAATAACGATAC--GGGGTC  TTCACAGGTCTC---GCAA-T  CGGAATGAGTACAATTTAAA
Beroe      CGCAAATTACCCAAATCC-G   ATTCGGGGAGGTAGTGAACAA  TAAATAACGTTCCAGGCGCC  ---AAYGG-CTTCTGCAG-T   CGGAATGAGTACAATATAAC
Mnemiopsi  CGCAAATTACCCAAATCC-G   ATTCGGGGAGGTAGTGAACAA  TAAATAACGGTTGCAGGCGCC  ---AAGGG-CTTCTGCAG-T   CGGAATGAGTACAATATAAC
Scypha     CGCAAATTACCCAAATCC-G   ACACAGGGAGGTAGTGAACAA  TAAATAACAATGCAGGGCCT  TTC--TGGTCTC--ATAA-T   CGGAATGAGTACAACTTAAA
Tripedali  CGCAAATTACCCAAATCC-TG  ACACAGGGAGGTAGTGAACAA  GAACTAACAATACATGGGCCT  TTC--TGGTCTC--GTAA-T   TGGAATGAGTACAACTTAAA
Trichopla  CGCAAATTACCCAAATCC--G  ACACGGGGAGGTAGTGAACAA  GAAATAACAATGCGGGGACTC  TC---TGG-CTTC-GTAA-T   CGGAATGAGTACAATTTAAA
Tetilla    CGCAAATTACCCAAATCCC-G  ACTCGGGGAGGTAGTGAACAA  TAAATAACAATGCTGGGCTC  TTG--TAGTCT--GGCAA-T   TGGAATGAGTCCAATCAAA
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Anemonia G  --TCCTTT--AACGAGGATCC  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATAT  TAAAGTTGTTGCAGTT--AAA
Hormathii   --TCCTTT--AACGAGGATCC  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATAT  TAAAGTTGTTGCAGTT--AAA
Narellanu   --CCTCTT--AACGAGGAACA  ATTGGAGGGGCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Lepidisis   --CCTCTT--AACGAGGAACG  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAACGTTGTTGCAGTT--AAA
Ostomisi    AACCTCTT--AACGAGGAACG  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Umbellula   --CCTCTT-CTCCGAGGAACT  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGTCGCCGG-TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Paramuric   --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
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Telatoa     --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Bellonell   --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Protoptil   --TCTCTT--AACGAGGAACA  ATTGGAGGGGCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATAC  TAAAGTTGTTGCAGTT--AAA
Anthomast   --CCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCTGCGG--TAATT  CCAGCTCCAATAGCGTATAC  TAAGTTGTTGCAGTT--AAA
Narellabo   --CCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Protodend   --TCTCTT--AACGAGGAACA  ATTGGAAGGGCCAAGTCTGGTG  CCAGC-CGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Tubipora    --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-CGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Paragorgi   --CCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCTGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Lophogorg   --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Chrysogor   --GCTCTT--AACGAGGAACG  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCTGCGG--TAATT  CCAGCTCCAATAGCGTATAC  TAAAGTTGTTGNAGTT--AAA
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Corallium   --CCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCTGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTTTAAA
Renilla     --TGTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
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Alcyonium   --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGGTTAATT   CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
C_kisch1    --CCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCTGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Lennalia    --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTC  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTTTAAA
Xenia       --TCTCTT--AACGAGGACCA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
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Melitella   --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Calcigorg   --TCTCTT--AACGAGGACCA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
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Coelogorg   --TTTCTT--AACGAGGACCA  ATTGGAGGGGCCAAGTCTGGTG  CCAGCC-GCCGCGG--TAAXX  CCAGCTCCAATAGCGTATTG  XXXXXXXXXXXXXXXXXXXXXX
Erythropo   A--CTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATAC  TAAAGTTGTTGCAGTT--AAA
Junceella   --TCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXXX
Heliop2     --TCTCTT--AACGAGGACCA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAAXX  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Plunigorg   XXXXXXXXXXXXXXXXXXXXX  XXXXXAGGGGCCAAGTCTGGTG  CCAGC-AGCCGCGG--TAATT  CCAGCTCCAATAGCGTATTG  TAAAGTTGTTGCAGTT--AAA
Dendro2     --CCTCTT--AACGAGGAACA  ATTGGAGGGGCCAAGTCTGGTG  CCAGC-AGCTGCGG--TAATT  CCAGCTCCATTAGCGTATAT  TAAAGTTGTTGCAGTT--AAA
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Hormathii  AAGCTCGTAGTTGGATTTCG  GGA--CGGGCGCGGCCGGTCC  G-CGCAAGGGTGTGTTACTG  ACCGGACTGTGTTCTTCCGC  AAAGACTGCATGTGCTCTTA
Narellanu  AAGCTCGTAGTTGGACTTCG  GGA--CGGTNCGGTCGGTCA  G-CCGCAAGGGTATGTCACTG  GCCGGGCTGTGTTCTTCCGC  AAAGACTGCGTGTGCTCTTA
Lepidisis  AAGCTCGTAGTTGGATTTCG  GAG--CGGGGCGGTTGGTCA  G-CCGCAAGGGTATGTCACTG  GGGGGCTGTGTTCTTCCGC  CAAGACTGCGTGTGCTCTTA
Orstomisi  AAGCTCGTAGTTGGATTTCG  GAG-CGGGGCG-TTGGTCA  G-CCGCAAGGGTATGTCACTA  GCCGGGCTGTTCTTCCGC  GCAGACTGCGGCGTGCTCTTC
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Bellonell  AAGCTCGTAGTTGGATTTCG  G-CT-CGACGGCGGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGACGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
Protoptil  AAGCTCGTAGTTGGATTTCG  GGG--CGGGGCGGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGACGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
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Narellabo  AAGCTCGTAGTTGGACTTCG  GGA--CGGTNCGGTCGGTCA  G-CCGCAAGGGTATGTCACTG  GCCGCCTGTGTTCTTCCGC  AAAGACTGCGTGTGCTCTTA
Protodend  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGGCGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
Tubipora   AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGGCGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
Paragorgi  AAGCTCGTAGTTGGATTTCA  GGA--CGGCACGGTTGGTCA  T-CCGCAAGGGCANTGTCACTG  GCTGCGGTTGGCGTCTTCCGC  GAAGACCGACGTGTGCTCTTA
Lophogorg  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGACGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
Chrysogor  AAGCTCGTAGTTGGATTTCG  GGA--CGGGGCGGTCGGTCA  G-CCGCAAGGGTATGCCACTG  CCAGGGCTGTGTTCTTCCGC  CCAGACTGCGGCGTGCTCTTA
Acanthopt  AAGCTCGTAGTTGGATTTCG  GGC--CGGCCCGGTTGGTAC  G-CCGCAAGAATANTGTCACTG  CAAGACTGGGCGTGCTCTTA  GCAGACTTCGCGTGCTCTTA
Clavulari  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGACGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
Corallium  AAGCTCGTAGTTGGATTTCG  GGT--CGGCTCGGTCGGTCA  ATCCGCAAGGAAATGCCACTG  GCTGGGTTNGTCGTCTTCCGC  GAAGACCGACGTGTGCTCTTA
Renilla    AAGCTCGTAGTTGGATTTCG  GGG--CGGGCGGTTGGTCGGTCA  G-CCGAAAGGTGTGTCACTG  GCCCGGGTTGGCGTCTTCCGC  CAAGACCGGGGTGTGCTCTTA
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Alcyonium  AAGCTCGTAGTTGGATTTCG  GGCT-CAAGCTCGTCGGTGTCT  G-CCGCAAGGGTGAGG-ACTG  GCAGACTTCGCGTGCTCTTA  GCAGACTTCGCGTGCTCTTA
C_kischi   AAGCTCGTAGTTGGATTTCG  GGG--CGGCTCGGTTGGTCA  T-CCGCAAGGGCATGGCCACTG  GCTGGGGTTNGTCGTCTTCCGC  GAAGACCGACGTGTGCTCTTA
Lemnalia   AAGCTCGTAGTTGGATTTCG  GGCT-CGACGAGACGGGTCT  G-CCGCAAGGGTANTGCTACTG  TCGGCGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
Xenia      AAGCTCGTAGTTGGATTTCG  GGCT-CGACGAGACGGGTCA  G-CCGCAAGGGTAG-TACTG  TCGACGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTTA
Calicogor  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGACGTCGTGTTCTTCCGC  CAAGACTAGCGTGTGCTCTTA
Euplexaur  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGACGGTCA  G-CCGTAAGGGTANTGTCACTG  GCCGGGCTGTGTTCTTCCGC  CAAGACTAGCGTGTGCTCTTA
Anthoptil  AAGCTCGTAGTTGGACTTCA  GGG--CGGCGGTGGTTGGTCA  G-CCGCAAGGGTATGTCACTG  TCGGGGCTGTGTTCTTCCGC  CAAGACTAGCGTGTGCTCTTA
Eunicea    AAGCTCGTAGTTGGATTTCG  GGCT-CGACGAGACGGGTCA  G-CCGTAAGGGTANTGTCACTG  TCGGGGTTGGCGTCTTCCGC  GCAGACTTCGCGTGCTCTTA
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Telestula  AAGCTCGTAGTTGGATTTCG  G-TG-CGGCGGCGGTTGGTCA  G-CCGCAAGGGTANTGTCACTG  GGCGGCGCCTCNCNTGTTCTTCCGC  CAAGACCGGCGTGTGCTCTTA
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Siphonogo  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGAGACGGGTCA  G-CCGWAAGGGTWTGTCACTG  TCGACGTTGGCGTCTTCCGC  GCAGACTAGCGTGTGCTCTTA
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Calcigorg  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGACGGTCA  G-CCGCAAGGGTATGTCACTG  TCGGCGTTGGCGTCTTTCCGC  GCAGACTTCGCGTGCTCTTA
Juncee2    AAGCTCGTAGTTGGATTTCG  GGG--CGGCGAGGCGGGTCA  G-CCGCAAGGGTATGTCACTG  GCCGGCGTCTCCTTTTGCT  CAAGACTAGCGGCGTGCTCTTA
Coelogorg  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXX
Erythropo  AAGCTCGTAGTTGGATTTCG  GGG--CGGCGGTTGGTCA  G-CCGCAAGGGTANTGTTACTG  GCCGGCCTGTCTCCTTTTCGC  CAAGACTAGCGGTGTGCTCTTA
Junceella  AAGCTCGTAGTTGGATTTCG  GGG--CGGGCGGGTGGGTCA  G-CCGCAAGGGTANTGTCACTG  GCCGGCGTGTCCTTTCCGC  CAAGACTAGAGGCGTGTGCTCTTA
Heliop2    XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXX
Plumigorg  AAGCTCGTAGTTGGATTTCG  GGCT-CGACGGCGACGGTCA  G-CCGCAAGGGTANTGTCACTG  TCGACGTTCGCGTGCTCTTCCGC  GCAGACTTCGCGTGCTCTTA
Dendro2    AAGCTCGTAGTTGGATTTCG  GGA--CGGCAC-GGTTGGTCA  ATCCCAAGGGCATGTCACTG  ACTGGTTGCGTCTTCTTCGC  GAAGACCAGTGTGTGTGCTCTTA
Selaginop  AAGCTCGTAGTTGGATTTCG  G-TG-TGGGCCAGTCGGGTCA  G-CCCAAGGGCCTGTTACTG  ACTGGTTCGCTGTCTTTCGC  AAAGACTGCACGTGCCCCGTC
Beroe      AAGCTCGTAGTTGGATTTCG  GAA--CCGGCC-GATTGGTCC  GTCCTCTCTCGGATCGTGTACTG  ATGGGTCTGTCTTCTCTCCGC  GAAGACCGACGGTGTGCCCTTA
Mnemiopsi  AAGCTCGTAGTTGGATTTCG  GAA--CCGGCC-GAATNGGTCC  GTCCTCGGATCCGTGTACTG  ATCGGTCMTGTCTTCTCTCGC  GBAGACCGGCGTGTGCCCCTCT
Scypha     AAGCTCGTAGTTGGATTTCG  GAG--CGGAGCT-CACGGTCC  G-CCTTTCGGGTGTGGCACT  GTCCTGATCGTCGTCTTCTTC  TCGTGGAGGGTGTGTGCGTCT
Tripedali  AAGCTCGTAGTTGGATTTCG  GGTT-GGAGTT-GACGGTCT  G-CGCTAGGGTANTGTCACT  TCCACTCNCGTCNCTTCTTGC  AGGGACTTCACATATCCTTA
Trichopla  AAGCTCGTAGTTGGATTTCG  GAAT-GAATCT-GACGGTCC  G-CCTAACCGGTG-AGTACTG  GATGATTGTNTCTCTTCTCTT  GAGGGCTGCANTATGCTCTTA
Tetilla    AAGCTCGTAGTTGGATTTCG  GGG--CAGCCCGCGGGGTCC  G-CGCACCA---AGTACTG  GTCGGGCG-CTCTTCCTCTC  GAAGGCTTCGACTGTCTTTC
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Anemoniad  ACTGAGTGTGCGC-G-GGAG  TTCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCCA--GCGCTTGAATACA  TAAGCATGGAATAATGGAAT
Hormathii  ACTGAGTGTGTG--TAGGAC  TTCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCCA--GCGCTTGAATACA  TAAGCATGGAATAATGGAAT
Narellanu  GCTGAGTGTG-GG-CAGGAT  TTCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  -GCTG--GCGGCTTGAATACA  TAAGCATGGAATAATGGAAT
Lepidisis  GTTGAGTGTG-CG-CAGGAT  TCCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTC--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Orstomisi  GTTGAGTGTG-CG-CAGGAT  TCCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTC--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Umbelluia  ACTGAGTGTG-CG-TTGGAT  TTGTGGCGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCGGTGTGCTTGGAAATGCG  TAAGCATGGAATAATGGAAT
Paramuric  ACTGAGTGTG-CG-TTGGAT  ACCCGACGTTTACTTTGAAA  AAATTGGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Acanthogo  ACTGAGTGTG-CG-TTGGAT  ACGTGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Talaroa    ACTGAGTGTG-CG-TCGGAT  TTGCGACGTTTACTTTGAAG  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Bellonell  ACTGAGTGTG-CG-TTGGAT  ACGCGACGTTTACTTTGAAA  AAATTAAAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Protoptil  ATTGAGTGTG-CG-TGGAT   TTCCGATGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTG--GCGCTTGAATACA  TAAGCATGGAATAATGGAAT
Anthomast  ACTGAGTGTG-CG-TGGAT   TTCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCATGGCA  GGGCTG--GTGCTCGGAATGG  TAAG-ATGGAATAATGGAAT
Narellabo  GCTGAGTGTG-GG-CAGGAT  TCCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTG--GCGGCTTGAATACA  TAAGCATGGAATAATGGAAT
Protodend  ACTGAGTGTGCG--TTGGAT  ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Tubipora   ACTGAGTGTCG--TCGGAT   ACGGGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Paragorgi  ATTGAGTGTGCC-A-TGGAAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTG--GAGCTTGAAATACA  TAAGCATGGAATAATGGAAT
Lophogorg  ACTGAGTGTGC--TTGGAT   ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Chrysogor  GCTGAGTGTCG--CGGGAT   TCCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGTG--GTGCTCGGAATGGG  TAAG-ATGGAATAATGGAAT
Acanthopt  GTTGAGTGTGCGC-ATGGAT  TGCCGCCGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Clavulari  ACTGAGTGTGCG--TTGGAT  ACGGGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Corallium  ATTGAGTGTGCC-A-TGGAAT  TTGCGACGTTTACTTTGAAG  AAATTAGAGTGTTCAAAGCA  GGGCTG--GCGCTTGAAATACA  TAAGCATGGAATAATGGAAT
Renilla    ACTGAGTGTGAGG--TAGGAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTG--GTGCTTGAAATACA  TAAGCATGGAATAATGGAAT
Stylatula  ATTGAGTGTG-GG-TAGGAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GGGCTTGAATACA  TAAGCATGGAATAATGGAAT
Virgulari  GTTGAGTGTG-TG-TAGGAT  TTGCGACGTTTACTTTGTAA  AAATTAGAGTGTTCAAAGCA  G-CTT--GGGCTTGAATACA  TAAGCATGGAATAATGGAAT
Leioptilu  ATTGAGTGTG-GG-TAGGAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Alcyonium  ACTGAGTGTGC-G-TTGGAT  ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
C_kischi   ATTGAGTGTGCAT--GGAAT  TTGCGACGTTTACTTTGAAG  AAATTAGAGTGTTCAAAGCA  GGGTA--GAGCTTGAAATACA  TAAGCATGGAATAATGGAAT
Lemnalia   ACTGAGTGTGGT-C-GGAT   ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Xenia      ACTGAGTGTGTGT-T-GGAT  ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Calicogor  ACTGAGTGTGCGT-C-GGAT  ACCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GGGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Euplexaur  ACTGAGTGTG--TTGGAT    ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Anthoptil  ATTGAGTGTGGG--TAGGAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Eunicea    ACTGAGTGTGCG--TCGGAT  ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Anthothel  ACTGAGTGTGCG--TTGGAT  ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Telestula  ATTGAGTGTGGG--TAGGAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Briareum   ACTGAGTGTGCTC--GGAT   TCGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCCT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Siphonogo  ACTGAGTGTGCG--TTGGAT  ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTC--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Melitella  ACTGAGTGTGCCG--TTGGAT  ACGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Calcigorg  ACTGAGTGTGCG--TTGGAT  ACCCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Juncee2    GCTGAGTGTGCG--TAGGAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Coelogorg  XXXXXXXXXXXXXXXXXXXX  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Erythropo  ATTGAGTGTGGG--TAGGAT  TTCGGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Junceella  ATTGAGTGTGGG--TAGGAT  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTC--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Heliop2    XXXXXXXXXXXXXXXXXXXX  TTGCGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Plumigorg  ACTGAGTGTGCG--TTGGAT  TTCCGACGTTTACTTTGAAG  AAATTAGAGTGTTCAAAGCA  GGGCTT--GTGCTTGGAATACA  TAAGCATGGAATAATGGAAT
Dendro2    ATTGAGTGTGCA--TGGAAT  TCGGGACTTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTT--GGAGCTTGAATACA  TCAGCATGGAATAATGGAAT
Selaginop  GCTGGGTGTGTGTATTGGAT  TTGAGACTTTACTTTGAAA   AAATTAGAGTGTTCAAAGCA  GGCTTTGAGGCTTGAATACA  TGAGCATGGAATAATGGAAT
Beroe      ACTGGGTGGGGCG--TGGGAT  TCGGGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCATT--CGCTTGAATATC  TCAGCATGGAATAATAGGAAT
Mnemiopsi  ACTGGGTGGGGCG--YGGGAT  TCGGGACTTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGCAGT--GGCTTGAATACA  TTAGCATGGAATAATAGAAT
Scypha     TCATTGAGTGTGCACGTAAC  TCGGGACTTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  GGGCTTT--GGCTTGAAATACA  TTAGCATGGAATAATGGAAT
Tripedali  ACTGGCTGTGTG--TAGGAT  TCCGGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAAGCA  AGCATACTAACTTGAATACA  TGAGCATGGAATAATGGAAC
Trichopla  ATTGAGTGTCGTGT--AGGAT  TTAAGACTTTACTTTGAAA   AAATTAGAGTGTTCAAAGCA  GGGCCAT--CGCTTGAATACC  TTAGCATGGAATAATAATGGAAT
Tetilla    ATTGTAATGGTCG--AAGAGT  TCGGGACGTTTACTTTGAAA  AAATTAGAGTGTTCAAGGCA  G-CCGT--CGCCTGA-TACA  TTAGCATGGAATAATGATGGAAG
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AnemoniaG  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACCT  GAAGTAATGATTAATGAGGGA  CAGTTGGGGGGCCATTCGTAT-  -T-CGTTGTGTCAGAGGTGAAA
Hormathii  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Narellanu  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACCC  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGCTGTGTCAGAGGTGAAA
Lepidisis  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Orstomisi  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Umbellula  AGGACTTTGGTTC--TATTTT  --GTTGGTT-CTTGGAACC-  GAAGTAATGATTGAATAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Paramuric  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Acanthogo  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Taiaroa    AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Bellonell  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTG-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Protoptil  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TAGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Anthomast  AGGACTTTGGTTC--TATTTT  --GTTGGTTCC-GGAACC-  GACGTAATGATTAATACAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGCTGTCAGAGGTGAAA
Narellabo  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Protodend  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Tubipora   AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Paragorgi  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGCTGTCAGAGGTGAAA
Lophogorg  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTG-TGGAACC-  GAAGTAATGATTAATACAGAGA  CAGTTGGGGGGCCACTCGTAT-  -TTACCGTCAGAGGTGAAA
Chrysogor  ATGACTTTGGTTC--TATTCT  --GTTGGTTTG-TAGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Acanthopt  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Clavulari  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Corallium  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TGGAACC-  GAAGTAATGATTAATAACAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Renilla    AGGACTTTGGTTC--TATTTC  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Stylatula  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TAGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Virgulari  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TAGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Leioptilu  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TAGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCGTATTCGTAT-  -TTCGTTGTCAAAGGTGAAA
Alcyonium  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
C.kischi   AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TGGAACC-  GAAGTAATGATTAATAACAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Lemnalia   AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Xenia      AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Calicogor  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Euplexaur  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGGTATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Anthoptil  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TAGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTCAGAGGTGAAA
Eunicea    AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGAATGAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Anthothel  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTB-TNGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Telestula  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Briareum   AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Siphonogo  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTY-TKGAACC-  GAAGTAATGATTAATAACAGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Melitella  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTY-TKGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Calcigorg  AGGACTTTGGTTC--TATTTT  CCGTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTCAGAGGTGAAA
Juncee2    AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TAGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Coelogorg  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX
Erythropo  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Junceella  AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TAGAACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Heliop2    XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX
Plumigorg  AGGACTTTGGTTC--TATTTT  --GTTGGTTTG-TGGAACC-  GAAGTAATGATTAATAAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTGTCAGAGGTGAAA
Dendro2    AGGACTTTGGTTC--TATTTT  --GTTGGTTTC-TGGAACC-  GAAGTAATGATTAACAGAGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGCTGTCAGAGGTGAAA
Selaginop  AGGACCTCGGTCGTCCCWTATTC  --GTTGGTTTTACGGA-CC-  GAAGTAATGATTAAGAGGGA  CAATTGGGG--CAYCCGTAT-  -TTCGTAGTCAGAGGTGAAA
Beroe      AGGACTTTGGTGTCT-TATTTT  --GTTGGTTTT-CCGAGACC-  GAAGTAATGATTAATAAGGGA  CAGTTGGGGG--AATCCGTAT-  -TTCATTGTCAGAGGTGAAA
Mnemiopsi  AGGACTTTGGTTC--TATTTT  --GTTGGTTTT-CCGAACC-  AAGGTAATGACTAATAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCATTGTCAGAGGTGAAA
Scypha     AGGACTTCGGGTCCC-GTTTT  --GTTGGTTTTACGGA-CC-  GACGTAATGATTAAGAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCAATGTCAGAGGTGAAA
Tripedali  AGGACTTCGGGTCC-C-GTTTT  --GTTGGTTTTCCGGAACC-  GAGGTAATGATTAAGAGGGA  CAGTTGGGGGGCCATTCGTAT-  -TTCGTTGTCAGAGGTGAAA
Trichopla  AGGACTTTGGTTC--TATTTT  --GTTGGTTTTT-CGGAACC-  GAAGTAATGATTAATAGGGA  CAGTTGGGGGGCCATTCGCGTA  CTTCAATGTCAGAGGTGAAA
Tetilla    AGACCT-CGGTCC-TATTTT  --GTTGGTTTT-TAGGGCC-  GAAGTAATGAATCAAGAGGGA  CAGTTGGGGGCCATTCGTATT  T--AATGTCAGAGGTGAAA
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AnemoniaG  TTCTTGGATTTACGRAAGAC  GAACTACTCGCGAAAGCATTT  GCCAAGAATGTTTTCATTAA  TCAAGAACGRAAGTTAGAGG  CTCGAAGAGCATCAGATACC
Hormathi   TTCTTGGATTTACGRAAGAC  GAACTACTCGCGAAAGCATTT  GCCAAGAAATGTTTTCATTAA TCAAGAACRAAGTTAGAGG   ATCGAAGAGCATCAGATACC
Narellanu  TTCTTGGATTTCGGRAAGAC  TTCAAGAATTCGGAAGAC    GTCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCATCAGATACC
Lepidisis  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCATCAGATACC
Orstomisi  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAANAGCATCAGATACC
Umbellula  TTCTTGGACCTCGGGAAGAC  GAACTAATGCGAAAGCATTC   GTCAGAGCCGTTTCCGTTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCATCAGATACC
Paramuric  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCATCAGATACC
Acanthogo  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCATCAGATACC
Talaroa    TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCATCAGATACC
Bellonell  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  --GRAGACGATCAGATACC
Protoptil  TTCTTGGATCTCGCGAAAGAC GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTGA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Anthomast  TTCTTGGATCTCGCGAAAGAC GAACTAATGCGAAAGCATTT   GTCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Narellabo  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTC   GTCAGAGCCGTTTCCGTTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Protodend  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Tubipora   TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Paragorgi  TTCTTGGATCTCGGGAAAGAC GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Lophogorg  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCATCAGATACC
Chrysogor  TTCTTGGACCGGTGGAAGAC  GAACCAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Acanthopt  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGGCTCAGATACC
Clavulari  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Corallium  TTCTTGGATCTCGCGAAAGAC GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Renilla    TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTGA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Stylatula  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCATGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Virgulari  TTCTTGGATTTCGGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Leioptilu  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Alcyonium  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
C_kischi   TTCTTGGATCTCGCGAAAGAC GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTGA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Lemnalia   TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Xenia      TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Calicogor  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Euplexaur  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Anthoptil  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Eunicea    TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Anthothel  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Telestula  TTCTTGGATTTACGRAAGAC  GAACCAGTGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAT TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Briareum   TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Siphonogo  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Melitella  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Calcigorg  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Juncee2    TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  XXXXXXXXXXXXXXXXXXXX
Coelogorg  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  XXXXXXXXXXXXXXXXXXXX
Erythropo  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Junceella  TTCTTGGATTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  GAACTAATGCGAAAGCATTT
Heliop2    XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX   XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Plumigorg  TTCTTGGGTTTACGRAAGAC  GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Dendro2    TTCTTGGATCTCGCGAAAGAC GAACTAATGCGAAAGCATTT   GCCAAGAAATGTTTTCATTGA TCAAGAACGRAAGTTAGAGG  ATCGAAGAGCGATCAGATACC
Selaginop  TTCTTGGACCTACGRAAGAC  GAACAACTGCGAAAGCATTT   GCCAAGAGTGTTTTCATTAA TCAAGAACGRAAGTTGGAGG  CTCGAAGAGCGATCAGATACC
Beroe      TTCTTGGATTTA-GRAAGAC  GAACTTCTCGCCGAAAGCATTT GCCAAGAGTGTTTTCATTAA TCAAGAACGRAAGTTGGAGG  CTCGAAGAGCGATCAGATACC
Mnemiopsi  TTCTTGGATTTATGRAAAGAC GCCAACTCGGAAAGCATTT    GCCAAGAGATGTTTTCATTAA TCAAGAACGRAAGTTGGAGG  ATCGAAGAGCGATCAGATACC
Scypha     TTCTTGGATTTATGRAAGAC  GAACAACTGCGAAAGCATTT   GCCAAGAGATGTTTTCATTAA TCAAGAACGRAAGTTGGAGG  TTCGAAGAGCGATCAGATACC
Tripedali  TTCTTGGATTTACGRAAGAC  GAACAACTGCGAAAGCATTT   GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTGGAGG  ATCGAAGAGCGATCAGATACC
Trichopla  TTCTTGGATTTATGRAAGAC  GAACAACTGCGAAAAGCATTT  GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTGGAGG  TTCGAAGAGACGATCAGATACC
Tetilla    T-CTCGGATTTATGAAAGAC  GAAAA-GTGCGAAAAGCATTT  GCCAAGAAATGTTTTCATTAA TCAAGAACGRAAGTTGGGGG  TTCGAAGAGACGATCAGATACC
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AnemoniaG  GTCCTAGTTATTAACCATAAA CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGGATGACC TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Hormathii  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GAGAGTGTTAATTGGATGACC  TCTTTGGGCACCTTAWGGAGAA ACCAAAGTTTTTGGGTTTCCG
Narellanu  GTCCTAGTTCTAACCATAAA  CGATGCCGACTGGGGAATC--A GCGGAGTGTTAATTGGATGACC CCGTTGGGCACCTTAAGAGAA  ACCAAAGTTTTTGGGTTTCCG
Lepidisis  GTCCTAGTTCTAACCATAAA  CGATGCCGACTGGGGAATC--G GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Orstomisi  GTCCTAGTTCTAACCATAAA  CGATGCCGACTGGGGAATC--G GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Umbellula  GTCCTAGTTCTAACCGTAAA  CGATGCCGACTAGGGGAATC--G GCGGATGTTAATTGGATGACC  CCGTCGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTNCCG
Paramuric  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGGATGACC  TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Acanthogo  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGGATGACC  TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Taiaroa    GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGGATGACC  TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Bellonell  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGGGTGTTAATTGGATGACC  TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Protoptil  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGGAATC--A GCGGGTGTTAATTTGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Anthomast  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTCAGGGGAA ACCAAAGTTTTTGGGTTTCCG
Narellabo  GTCCTAGTTCTAACCATAAA  CAATGCCGACTAGGGGAATC--A GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Protodend  GTCCTAGTTCTAACCATAAA  CGATGCCGACTTGGGATC--A GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Tubipora   GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGGGTGTTAATTGGATGACC  CCGTTGGGCACATTAWGGGAA  ACCAAAGTTTTTGGGTTTCCG
Paragorgi  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--G GCGGGTGTTAATTGGATGACC  CCGTCGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Lophogorg  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--A GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Chrysogor  GTCCTAGTTCTAACCATAAA  CGATGCCGACTGGGGATC--A GCGGATGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Acanthopt  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--G GCGGGTGTTAATTGGATGACC  CCGTCGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Clavulari  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGATGACC   TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Corallium  GTCCTAGTTCTAACCATAAA  CGATGCCAACTAGGGATC--A GCGGGTGTTAATTGGATGACC  TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Renilla    GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGGATC--G GCGAGTGTTAATTGTATGACC  CCGTCGGCACCTTAWGGGGAA  ACCAAAGTTTTTGGGTTTCCG
Stylatula  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGGGTGTTAATTGTATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Virgulari  GTCCTAGTTCTAACCATAAA  CCATGCCGACTAGGGATG--A GCGGGTGTTAATTGTATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Leioptilu  GTCCTAGTTCTCAACCATAAA CGATGCCGACTAGGGAATC--A GCGGGTGTTAATTGTATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Alcyonium  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
C.kischi   GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGGGTGTTAATTGGATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Lemnalia   GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--A GCGGGTGTTAATTGTATGACC  TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Xenia      GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGTATGACC  TCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Calicogor  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Euplexaur  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Anthoptil  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Eunicea    GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Anthothel  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Telestula  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Briareum   GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--G GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Siphonogo  GTCCTAGTTCTAACCATAAA  CGATGCCACVAGGGATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Melitella  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Calcigorg  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGAATC--A GCGAGTGTTAATTGTATGACC  TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Juncee2    GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--G GCGGGTGTTAATTGTATGACC  CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Coelogorg  XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX GCGGGTGTTAATTGTATGACC  CCGTTGGGCACCTTAWGGGGAA XXXXXXXXXXXXXXXXXXXXX
Erythropo  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--A GCGGGTGTTATTGTATGACC   CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Junceella  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--A GCGGGTGTTATTGTATGACC   CCGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Heliop2    XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX
Plumigorg  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATC--A GCGGGTGTTATTGTATGACC   TGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Dendro2    GTCCTAGTTCTAACCATAAA  CGATGCCAACTAGGGATC--A GCGGGTGTTATTGTATGACC   CGGTTGGGCACCTTAWGGGGAA ACCAAAGTTTTTGGGTTTCCG
Selaginop  GTCCTAGTTCCAACCOTAAA  CGATGCCGACTAGGGATC--A GCGGGTGTTATTGTGGGACC   CCGTTGGGCACCTCACGGGAA  ACCAAAGTTTTTGGGTTTCCG
Beroe      GTCCTAGTTCCAACCATAAA  CGATGCCGTCTGTCGGATC--G GAGGTCGCTCAATAAAGGCT  CCTTCGGCACGCTATGAGAA   ATCAAAGACTTCGGGTTTCCG
Mnemiopsi  GTCCTAGTTCCAACCATAAA  CGATGCCGTCTGTCGGATC--G GTGGATGTTATATAAAACT    CCATCGGCCACCTTATGAGAA  ATCAAAGATTTTGGGTTTCCG
Scypha     GTCCTAGTTCCAACCATAAA  CGATGCCGACTAGGGATC--G GTGGATGTTATATAAATGACC  CCGTGGCACCTTATGGGAA    CCCAAGTTGTTTGGGTTTCCG
Tripedali  GTCCTAGTTCTAACCATAAA  CGATGCCGACTAGGGATT--A GCGGGCGTTATTGTATGACT   CCGTTGGGCACCTTATGGGAA  ACCAAGTTTTTGGGTTTCCG
Trichopla  GTTGTAGTTCTAACCATAAA  CGATGCCGTCTCAGGGGATC-A GTTGAGTGTATTAATAAGACT  CCGTTGGGCACCTTAAGGGAA  ACCAAAGTATTTGGGTTTCCG
Tetilla    GTCGTAGTCCCAACCATAAA  CTATCCGACTAGGGATCGG   CGGATGTTAGGGCTCGACTC   CGTCGGCACCTTGGGAGAAA   TCAAGAGTCTTTGGGTTTCCG
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Anemoniag  GGGGAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CG-CTTAAT  TTGACTCAACACGGGGAAAC
Hormathii  GGGGAAGTATGGTTGCAAAT  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Narellanu  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGGCAG--TG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Lepidisis  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AXX--G-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Orstomisi  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGGC---XG-CGGCTTAAT   TTGACTCAACACGGGGAAAC
Umbellula  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Paramuric  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Acanthogo  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTA-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Talaroa    GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Bellonell  GGGGAAGTATGGTCGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Protoptil  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Anthomast  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Narellabo  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Protodend  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAANNNNATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Tubipora   GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Paragorgi  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Lophogorg  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Chrysogor  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Acanthopt  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAC
Clavulari  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAACC
Corallium  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAACC
Renilla    GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAACC
Stylatula  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAACC
Virgulari  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AC--TG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Leioptilu  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Alcyonium  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AC--TG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
C_kischl   GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAACC
Lemmalia   GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAACC
Xenia      GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAACC
Calicogor  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AC--TG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Euplexaur  GGGGAAGTATGGATGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Anthoptil  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Eunicea    GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTGCGCGCTTAAT  TTGACTCAACACGGGGAAAAC
Anthothel  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Telestula  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Briareum   GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Junceee2   XXXXXXXXXXXXXXXXXXXX  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Coelogorg  XXXXXXXXXXXXXXXXXXXX  CTGAAACTTAAAGGAATTGA  CGGARGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Siphonogo  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Melitella  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Calcigorg  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Juncee2    XXXXXXXXXXXXXXXXXXXX  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Erythropo  GGGGAAGTATGGTTGCAAAG  CCGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Junceella  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Heliop2    XXXXXXXXXXXXXXXXXXXX  CTGAAACTTAAAGGAATTGA  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Plumigorg  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Dendro2    GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Selaginop  GGGGAAGTATAGTTGCGAAGA  CCGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTGGCGGGCTTAAT TTGACTCAACACGGGGAAAAC
Beroe      GGGGAGTATGGTCGCGAAGA  -TGGAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG----CTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Mnemiopsi  GGGGAGTATAAATCGGAAGA  ATGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AACCTG-CGG-TTAAT  TTGACTCAACAC-GGG-AAAAC
Scypha     GGGGGAGTATAAACCGGAAG  TCGGAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TG-----CTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Tripedali  GGGGAAGTATGGTTGCAAAG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGGCTTAAT  TTGACTCAACACGGGGAAAAC
Trichopla  GGGGGAAGTATGGTTGCAAAG CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TGG-AGCCTG-CGC-TTAAT  TTGACTCAACACGGGGAAAAC
Tetilla    GGGGGAGTATGGTCGCAAGG  CTGAAACTTAAAGGAATTGA  CGGAAGGGGCACCACCAGGAG  TG--AGCCTG-CGC-TTAAT  TTGACTCAACACGGGGAAAC
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Anemoniac   TCACCAGGTCCAGACATAGG  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTNNT
Hormathii   TCACCAGGTCCAGACATAGG  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Narellanu   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Lepidisis   TCACCAGGTCCGGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Orstomisi   TCACCAGGTCCGGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGC
Umbellula   TCACCAGGTCCAGACATAGC  GAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGT  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTCTGT
Paramuric   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTNT
Acanthogo   TCACCAGGTCCAGACATAGT  AAGGATTNACAGATTNANAG  CTCTTTCTTGAATTCTAATNNN  TGGTGGTGCATGGNCCGTTCT  TAGTTGGTGGTGGAGTGAATTTNT
Taiaroa     TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Bellonell   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Protoptil   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Anthomast   TTACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Narellabo   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Protodend   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Tubipora    TTACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Paragorgi   TTACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Lophogorg   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Chrysogor   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Acanthopt   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Clavulari   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Corallium   TTACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTCTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Renilla     TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Stylatula   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGACAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Virgulari   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCCT  TAGTTGGTGGTGGAGTGAATTTGT
Leioptilu   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Alcyonium   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
C_kischi    TTACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAATGAATTTGT
Lemmalia    TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Xenia       TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Calicogor   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Euplexaur   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Anthoptil   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Eunicea     TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Anthothel   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Telestula   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGACAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Briareum    TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Siphonogo   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Melitella   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Calicgorg   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Juncee2     TCACCAGGTCCAGATATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Coelogorg   XXXXXXXXXXXXXXXXXXXX  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX
Erythropo   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Junceella   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Heliop2     XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX
Plumigorg   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Dendro2     TTACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGA  TGGTGGTGCATGGCCGTTCT  TAGTTCGTGGGAATGAATTTGT
Selaginop   TCACCAGGTCCAGACATAGG  AAGGATTGACAGGTTGAGAG  CCCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Beroe       TCACCAGGTCCAGACATAGG  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Mnemiopsi   TCACCAGGTCCAGACATAGG  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Scypha      TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Tripedali   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
Trichopla   TCACCAGGTCCAGACATAGT  AAGGATTGACAGATTGATAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGAGTGAATTTGT
Tetilla     TCACCAGGTCCGGACATGGT  AAGGATTGACAGATTCGAGAG  CTCTTTCTTGAATTCTAATGGG  TGGTGGTGCATGGCCGTTCT  TAGTTGGTGGTGGAGTGAATTTGT
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AnemoniaG  CTGGTTAATTCCGTTAACGA  ACGAGACCTTAACCTGCTAA  ATAGTTACGCCCATGCGGAT  GGGCA--ACTA--------  ACTTCTTAGAGGGGACTGTTG
Hormathii  CTGGTTAATTCCGTTAACGA  ACGAGACCTTAACCTGCTAA  ATAGTCACGCGAAATCCCGAN  TCGCG--GCTG--------  ATAGTCAGAGGGGAACTGTTG
Narellanu  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCCGGACGATTCCCGAA  TCGTG--CACG--------  GCTTCTTAGAGGGGACTGTTG
Lepidisis  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGGCCTGCTAA  ATAGTCGGACGAGATTCTCGAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Orstomisi  CTGGTTAATTCCGATTAACGA  ACGAGACCTGGGCCTGCTAA  ATAGCAGGGACGAATTGTCGAA  TGGTG--CACG--------  ACTTCTTAGAGGGGACTGTTG
Umbellula  CTGGTTAACTCCGATTAACGA  ACGAGACCTGACCTGCTAA  CTAGTCAGTAGATTCAAGAA  TCGAC--GGTG--------  ACTTCTTAGAGGGGACTGTTG
Paramuric  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCAAGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Acanthogo  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCAAGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Tatatoa    CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCGGCAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Bellonell  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCGGCAA  TCGTA--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Protoptil  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCGGGCGGACGATTCGGAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Anthomast  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCGGACGAGATTCCCGAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Narellabo  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCGGACGAGATTCTCGAA  TCGTG--CACG--------  ACTTCTTAGAGGGGACTGTTG
Protodend  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCAAGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Tubipora   CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAATTCCCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Paragorgi  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCAAGAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Lophogorg  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCCGGTCGATTGCGGAA  TGGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Chrysogor  CTGGTTAATTCCGTTAACGA  CTGAGACCTCGCGATTTCGGAA  CTAGTCTCGTCGATTTTCGAA  CCGTT--TTAG--------  GCTTCTTAGAGGGGACTGTTG
Acanthopt  CTGGTTAATTCCGATTAACGA  ACGAGACCTTGACCTGCYAA  ATAGTCGGACGATTCCCGAA  TCGTC--CTCG--------  GCTTCTTAGAGGGGACTGTTG
Clavulari  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCAAGAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Corallium  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCGGCGTCGATTCAAGAA  TGGCA--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Renilla    CTGGTTAATTCCGTTAACGA  ACGAGACCTTGATCTGCTAA  ATAGTCGGACGAATTCGGGAA  TCCTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Stylatula  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGTCCTGCTAA  ATAGTCAGACGAATTCAAGAA  TTGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTT-
Virgulari  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCGGGCGATTCGGGAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Leioptilu  CTGGTTAATTCCGTTAACGA  ACGAGACCTGTCTTGCTAA  ATAGTCTGCGATTCTCGAA  TCGTC--CACG--------  GCTTCTTAGAGGGGACTGTTG
Alcyonium  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCGGCAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
C_kischi   CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGGCGAGATTCCCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Lemnalia   CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCCCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Xenia      CTGGTTAATTCCGTTAACGA  ACGAGACCTGATCTGCTAA  ATAGTCAGACGAATTCCCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Calicogor  CTGGTTAATTCCGTTAACGA  ACGAGACCTGTCCTGCTAA  ATAGTCAGACGAATTCAAGAA  TTGCT--CTCG--------  ACTTGTTAGAGGGGACTGTTG
Euplexaur  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCGGGCGATTCTCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Anthoptil  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAATTCAAGAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Eunicea    CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAATTCTCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Anthothel  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGGCGAGATTCGGCAA  TCGTC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Telestula  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGGCGAGCTACTCGAA  TCGTCC--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Briareum   CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAATTCACGAA  TGGCGTTGC--------  ACTTCTTAGAGGGGACTGTTG
Siphonogo  CTKGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAGATTCGGGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Melitella  CTGGTTAATTCCGTTAACGA  ACGAGGCCCGACCTGCTAA  ATAGTCAGACGAATTGGGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Calcigorg  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCGAGACGAATTCCCGAA  TCG--CTCYCG--------  ACTTCTTAGAGGGGACTGTTG
Juncee2    CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGGATTCCCGAA  TCGT--GCTCG--------  GCTTCTTAGAGGGGACTGTTG
Coelogorg  XXXXXXXXXXXXXXXXXXXX  ACGAGACCTTGACCTGCTAA  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Erythropo  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGGCGGATTCTCGAA  TCG--TCCTCG--------  GCTTCTTAGAGGGGACTGTTG
Junceella  CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGATTCTCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Heliop2    XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Plumigorg  XXXXXXXXXXXXXXXXXXXX  ACGAGACCTTGACCTGCTAA  ATAGTCAGACGAATTCCCGAA  TCGCT--CTCG--------  ACTTCTTAGAGGGGACTGTTG
Dendro2    CTGGTTAATTCCGTTAACGA  ACGAGACCTTGACCTGCTAA  ATAGTCAGTCGAGATTCCCGAA  TC-GTCCTCG--------  XXXXXXXXXXXXXXXXXXXX
Selaginop  CTGGTTAATTCCGATTAACGA  ACGAGACCTTGACCAGCTAA  ATAGTGACACGGCTAATTTA  TTAGCAGCAATTCCAAAGTA  ACTTCTTAGAGGGGACTGTTG
Beroe      CTGGTTAATTCCGTTAACGA  ACGAGACCTTAACCTGCTAA  ATAGTCACACGGTTCTTTGA  ACCGTGGCTC--------  ACTTCTTAGAGGGGACTATTCG
Mnemiopsi  CTGGTTAATTCCGTTAACGA  ACGAGACCTTAACCTGCTAA  ATAGTTAAGCGGATTTTTTGA  XXXXXXXXXXXXXXXXXXX  ACTTCTTAGAGGGGACTGTTG
Scypha     CTGGTTAATTCCGTTAACGA  ACGAGACCTTAACCTGCTAA  ATAGTTACGCGCAATTCCGAA  TC-GCGGCCA--------  ACTTCTTAGAGGGGACTGTTG
Tripedali  CTGGTTAATTCCGTTAACGA  ACGAGACCTTAACCTGCTAA  ATAGTTAGGCGGATTCTGAA  TC-GTGGTTA--------  ACTTCTTAGAGGGGACTATTG
Trichopla  CTGGTTAATTCCGTTAACGA  AGGAGACCCTTATCCTACTAA  ATAGTTAGGTGTTCTAGGA  AC-ACGCGA--------  ACTTCTTAGAGGGGACACCGG
Tetilla    CTGGTTAATTCCGTTAACGA  ACGAGACCCTAACCTGCTAA  CTAGTCAGCGCCGTCCGAA  -CGCGGCCG--------  ACTTCTTAGAGGGGACTGTTG
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Anemoniac  --GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGTCAACGAGTTCT-
Hormathii  --GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCCACACNG ACGATGTCAACGAGTTCT-
Narellanu  --GTGATCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACTATGGCAACGAGTTGCT-
Lepidisis  --GTGATCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTGCT-
Orstomisi  --GTGATCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTGCT-
Umbellula  GTGTCTGTGAACCAAAGTCAG AAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTGCT-
Paramuric  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Acanthogo  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Talaroa    C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Bellonell  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Protoptil  C-GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Anthomast  --GTTTCAACCAGAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGCGCGCTACACTG GCCGAGTCAGCGAGTTGCT-
Narellabo  --GTGATCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACTATGGCAACGAGTTGCT-
Protodend  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Tubipora   C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Paragorgi  --GTGTTCAACCAGAGTCAG GAAGGCAATAACAGGTTCTGG GATGCCCTTAGATGTTCTGG ACCGCACGCGCGCTACACTG ACGATGTCAAGGAGTTGCT-
Lophogorg  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTGCT-
Chrysogor  --GTGATCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTGCT-
Acanthopt  --GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Clavulari  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Corallium  --GTGTTCAACCAGAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGCGCGCTACACTG ACGATGTCAAAGAGTTGCT-
Renilla    --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTGCT-
Stylatula  --GTGTTCAACCAAAGTCGG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTCTTT
Virgulari  --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTTCGTT
Leioptilu  --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ATGATGTCAGCGAGTTGCG-
Alcyonium  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
C_kischi   --GTGTTCAACCAGAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGCGCGCTACACTG ACGATGTCAAAGAGTTGCT-
Lemnalia   C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGTT-
Xenia      C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGCGCGCTACACTG ACGATGGCAACGAGTTCGC--
Calicogor  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGGCTGT GATGCCCTTAGATGTTCTGG GCCGCGCGCGCGCTACACTG TCGATGTCAACGAGTCGC--
Euplexaur  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Anthoptil  --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ATGATGTCAGCGAGTTGTT-
Eunicea    C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Anthothel  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Telestula  --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Briareum   --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Siphonogo  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCGCGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Melitella  T-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Calcigorg  C-GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAACGAGTCGCT-
Juncee2    --GTGTTCAAGCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGCAGCGAGTCGCT-
Coelogorg  XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX GCCGCACGCGCGCTACACTG XXXXXXXXXXXXXXXXXXXX
Erythropo  --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCGCTACACTG ACGATGGGCAGCGAGTCGCT-
Junceella  --GTGTTCAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTCCTGG GCCGCACGCGCGCTACACTG ACGATGGGCAGCGAGTCGCT-
Heliop2    XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX
Plumigorg  XXXXXXXXXXXXXXXXXXXX GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGCGTGCTACAATG AGGATGTCAAAGAGTTGCT-
Dendro2    --GTGTTCAACCAGAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCCGCACGCGCTGCTACACTG GTGAATACAGCGAGTATCCA
Selaginop  --GTGTTTAACCAAAGAAAG AAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG ACCGCACGGCTGCTACACTG ATGAAGCCAGCGAGTATATC
Mnemiopsi  CTTTCAAACCGATGGAAGTT TGAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCC--ACGCGCGTTACACTG ATGAAGCCAGCGAGTTCTT-
Beroe      GTTTTAAACCGATGGAAGTT TGAGGCAATAACAGGTCTGT GATGCCCTTAGATGTCTGG GCCCACGCGCGGTACACTG ATGAAGCCAGCGAGTATATC
Scypha     GTGTTTAAACCAAAGTAGTT GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCGGCACGCGCGGTTACACTG ACGATGGCAGGGAGTTAGC-
Tripedali  --GTGTTTAACCAAAGTCAG GAAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTGG GCGGCACGCGCGGTACACTG ACGATGGCAGGGAGTCTGAC
Trichopla  --GCGTTTAGCCAAAGTAAG TAGGGCATAACACAGGTCTGT GATGCCCTTAGATGTCTGG GCGACGGCGGC--TACACTG ATGAAGGGCAGAGAGT-----
Tetilla    CCCCGAAGCCGGCGGAAGTC TGAGGCAATAACAGGTCTGT GATGCCCTTAGATGTTCTCG GCCGCACGCGCGCTACACTG ACGGAGGCAGGGAGGACCATGT-
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AnemoniaG    ---CCTTGGCCGAAAGGTCT  GGG--TAATCTTCTCAAACAT  CGTCGTGCTGGGGGATAGATC  AATTGCAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Hormathii    ---CCTTCGCCGATAGGCGT  GGG--TAATCTTCTCAAACAT  CGTCGTGCTGGGGGATAGATC  AATTGCAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Narellanu    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTCTGAAATCAT  AGTCGTGCTGGGGAATAGATC  GTTTGTAATTATCGGATCTTGA  ACGAGGAATTCCTAGTAAGC
Lepidisis    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGAATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Orstomisi    ---CCTTCGCCGAA--GGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Umbellula    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTTGCAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Paramuric    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Acanthogo    ---CCTTCACCGAAAGGTNT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAAAAATTCCTAGTAAGC
Taiaroa      ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Bellonell    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTNGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Protoptil    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGAATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Anthomast    ---CCTTCACCGAAAGGTGT  GGG--TAACCTTCTGAAATCAT  CGTCGTGACAGGGGAATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Narellabo    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTCTGAATCAT  AGTCGTGCTGGGGGATAGATC  GTTTGTAATTATCGGATCTTGA  ACGAGGAATTCCTAGTAAGC
Protodend    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Tubipora     ---CCTTCACCGGAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Paragorgi    ---CCTTCATCGACAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGATGGGGAATAGATC  AATTGCAATTATTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Lophogorg    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Chrysogor    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Acanthopt    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTCTGAAATGT  CGTCGTGCTGGGGGATAGGCC  GTTTGTAATTTTCGGCCTTGA  ACGAGGAATTCCTAGTAAGC
Clavulari    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Corallium    ---CCTTCATCGAAAGGTGT  GGG--TAATCTTCTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Renilla      ---CCTTCACCGAAAGGTGT  GGG--TAATCTTTTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Stylatula    ---CCTTCATGAAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Virgulari    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Leioptilu    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTCTGTATAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Alcyonium    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGA--C  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGT
C_kischl     ---CCTTCATCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGAATGGGGAATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Lemnalia     ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGAATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGT
Xenia        ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Calicogor    ---CCTTCACCGAAAGGTGT  GGG--TGATCTTCTCTATCAT  CG--CGTGCTGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Euplexaur    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Anthoptil    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Eunicea      ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Anthothel    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGG--ATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Telestula    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Briareum     ---CCTTCGCCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Siphonogo    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Melitella    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Calicgorg    ---CCTTCACCGAAAGGTGT  GGGGTAATCTTCTCAAACAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Juncee2      ---CCTTCACCGTAAGGTGT  GGG--TAATCTTGTGAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Coelogorg    XXXXXXXXXXXXXXXXXXXX  GGG--TAATCTTGTGAAACAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  XXXXXXXXXXXXXXXXXXXX
Erythropo    XXXXXXXXXXXXXXXXXXXX  GGG--TAATCTTGTGAAACAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTCTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Junceella    ---CCTTCACCGAAAGGTGT  GGG--TAATCTTCTGAAATCAT  CGTCGTGCTGGGGGATAGATC  AATTGTAATTTTTGATCTTGA  ACGAGGAATTCCTAGTAAGC
Heliop2      XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Plumigorg    XXXXXXXXXXXXXXXXXXXX  GGG--TAATCTTCGGAATCAT  CATCGTGTCTGGGGATAGACC  CTTGCAATTAATGATCTTGA  ACGAGGAATTCCTAGTAAGC
Dendro2      ---CCTTCATCGAAAGGTGT  GGG--TAATCTTCGGAAAGTT  CATCGTGACAGGGGATTGATC  AATTGCAATTAATGATCTTGA  ACGAGGAATTCCTAGTAAGC
Selaginop    TTCCCTTGACCGGAAGGGTGT  GGG--TAATCTTGTGAAATGTT  TATCGTGCTGGGGATAGACC  CTTGCAATTAATGGTCTTGA  ACGAGGAATTCCTAGTAAGC
Beroe        G---CCTTCACCGAAAGGTGC  GGG--TAATCTTGTGAAACTT  CATCGTGCTGGGGGATAGACC  CTTGCAATTAATGATCTTGA  ACGAGGAATTCCTAGTAAGC
Mnemiopsi    G---CCTTCACCGGAAGGTGT  GGG--TAATCTTGTGAAACTT  CATCGTGTGATGGGGATAGACC  AATTGCAATTAATGGTCTTCA  ACGAGGAATTCCTAGTAAGC
Scypha       ---CCTTCACCGGAAGGTGT  GGG--TAATCTTTGTGAAACAT  CATCGTGTGATGGGGATAGACC  AATTGCAATTAATGATCTTGA  ACGAGGAATTCCTAGTAAGC
Tripedali    ---CCTTCACCGGAAGGTGT  GGG--TAATCTTCGGAAAGTT  CATCGTGTAATGGGGATAGATC  AATTGCAATTAATGATCTTGA  ACGAGGAATTCCTAGTAAGC
Trichopla    CCTGCTACACTGGGAGGTGC  GGC--TAATCTTTC-AAACTT  CATCGTGCTGGGGATAGATC  CTTGTAATTAATGGTCTTGA  ACGAGGAATTCCTAGTAAGC
Tetilla      ---CTTCGCCGATAGGTGC  GGG--GAATCTTGTGAAACTC  CGTCGTGCTGGGGATAGATC  AATTGCAATTCCGATCTTGA  ACGAGGAATTCCTAGTAAGC
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AnemoniaG  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGACTCCCTGATTGG-CGC
Hormathii  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGACTCCCTGATTGG-CGC
Narellanu  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CGC
Lepidisis  ACGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CAC
Orstomisi  ACGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CAC
Umbellula  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CTC
Paramuric  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TGCCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CAC
Acanthogo  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CAC
Taiaroa    GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Bellonell  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CGC
Protoptil  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGACTCCCGGATTGG-CGC
Anthomast  GCGAGTCATCAACTCGCGTT  GATTACGTCCCTGCCCCTTTG  TGCACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCCCTGGATTGG-CGC
Narellabo  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTCC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CGC
Protodend  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Tubipora   GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Paragorgi  GCGAGTCATCAACTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Lophogorg  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Chrysogor  GCGAGTCAACAACTCGCGTT  GATTACGTCCCTNCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGC-TTCGGATTGG-CAC
Acanthopt  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGATTCGTGGATTGG-CAC
Clavulari  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Corallium  GCGAGTCATCAACTTCGCGTT GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTTTGCAC
Renilla    GCGGAGTCATCAGCTCGCGTT GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTANAGT  GAGGACTCCGGATTGG-CGC
Stylatula  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CGC
Virgulari  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGACTCCGGATCCG-CGC
Leioptilu  GCGAGTCATCAGCTTCGCGTT GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGACTCCGGATCCG-CGC
Alcyonium  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACAATGCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
C.kischl   GCGAGTCATCAACTTCGCGTT GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTGG-CAC
Lemnalia   GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Xenia      GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Calicogor  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGC-TCCGGATTGG-CAC
Euplexaur  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Anthoptil  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGACTCCGGATCCG-CAC
Eunicea    GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Anthothel  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Telestula  GCGAGTCATCATCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATCCG-CGC
Briareum   GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATCCG-CGC
Siphonogo  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Melitella  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Calcigorg  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Juncee2    GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Coelogorg  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATTGG-CAC
Erythropo  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCAGATCGG-CAC
Junceella  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGCCTCCGGATCGG-CAC
Heliop2    XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Plumigorg  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXX
Dendro2    GCGAGTCATCAACTTCGCGTT GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGATCTCTGGATTGG-CTG
Selaginop  GCGAGTCATCANCTCGCGTTT GATTACGTCCCTGCCCCTTTG  TACACAC-GCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGATCTCGGGATTGGCATG
Betoe      ACGAGTCATCAACTCGTGCT  GATTACGTCCCTGCCCTTTG   TACACAC--GCCCGTCGCTAC TACCGATTGAATGGTTTAGT  GAGGCCTTCGGATTTTGTAC
Mnemiopsi  ACGAGTCATAACTACTCGTGCT GATTACGTCCCTGCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GACAATCGCGGATTGGCGAC
Scypha     GCAAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCTTTG   TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGATCTTCGGGATTGGCTGC
Tripedali  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCTTTG   TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGGATCCGGGATTGGCAGC
Trichopla  GCGAGTCATCAGCTCGCGTT  GATTACGTCCCTGCCCCTTTG  TACACACCGCCCGTCGCTAC  TACCGATTGGATGGTTTGAT  GAGGTCTTCGGATTGGTGAT
Tetilla    GCGAGTCAGCAGCTCGCGTT  GATTACGTCCCTGCCCTTTG   TACACACCGCCCGTCGCTAC  TACCGATTGAATGGTTTAGT  GAGATCTTCGGGATTGGACGG
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AnemoniaG  C-G--CG-------CCCCGGCCAC  GGAGCAGCGGACTGCC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Hormathii  C-GCCG-------CCCCGGCCAAC  GGAGCAGGGGACTGCC-GAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Narellanu  T-GTCGGAG----TTG-CAAG  ACTCTGACCGAGGCTC-GAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Lepidisis  T-GTCGGAG----TCG-CAAG  GTTCTGACCGAGGTCC-AAC  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Orstomisi  T-GTCGGAG----TCG-CAAG  AATCTGACCGAGGAGGTCC-GAA  AAGTCGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Umbellula  C-GTCGTG----TTCG-AAAG  AATCTGACCGAGC-GTC-GAA  AAGTCGGTCAAACTTGCTCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Paramuric  T-GTCAGATGGGCTTCGGGCT  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Acanthogo  T-GTCAGATGGGCTTCGGGCT  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Taiaroa    T-GTCAGATGGGCTTCGGGCT  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCG  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Bellonell  T-GTCGGATT----CGCAAG  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Protoptil  T-GTCGGATT----CGCAAG  ACTCGGACCGGAG-GCC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Anthomast  T-GTCGGATT----CGAAAG  AGCCTGGCGGTC-GCT-GAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Narellabo  C-GTCGGAGTT----GTAAG  ACTCTGACGGAA-GCTTGAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Protodend  T-GTCAGATGGTCTTCGGGCT  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Tubipora   T-GGTAGACGGGCTTCGGGTT  CGTCCGCCGGAC-GTC-AAA  AAGTCGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Paragorgi  T-GTCAGATGGGCTTCGGGTT  AGCCTGACGGAC-GTC-AAA  AAGTCGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Lophogorg  T-GTCAGATGGGCTTCGGTT  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Chrysogor  C-GTTG----GCCCCGCAAAG  GG-CGGATGGAA-GTC-GAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Acanthopt  T-GTCGGATT---CGC-AAG  TGTCTGACGGAC-GCC-GAG  AAGCTATTCGAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG-
Clavulari  T-GTCAGATGGGCTTCGGGCT  CATCCGACCGGAC-GTC-AAA  AAGTCGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Corallium  T-GTCGGGTT----CGAAAG  AGCCTGACGGCC-GCC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Renilla    T-GTCGGGTT----CGTAAG  ACTCTGACCGGAG-GCC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Stylatula  T-GTCGGATT----CGCAAG  AAGCTGACCGGAG-GTC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Virgulari  T-GTCGGTT----CGCAAG  GAGCTGACGGAG-GTC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Leioptilu  T-GTCGGATT----CGCAAG  ATTCTGACGGAG-GTC-GAG  AAGTTGTGTTACAAACTTGAGCA  TTTTATAGGGGAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Alcyonium  T-GTCAGATGGGCTTCCGGCC  CATCCGACGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
C_kischl   T-GTCGGGTT----CGAAAG  AGCCTGACGGCC--GCC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  CGTAACAAGGTTTCCGTAGG
Lemnalia   T-GTCAGATGGACTTACGGGTT  CATCCGACGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Xenia      TTGTCAGAATCAGCTTCGGCT  TATCCGACGGGAC-GTC-AAG  AAGCTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Calicogor  T-GTCAGATGGGCTTCGGCT  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Euplexaur  T-GTCAGATGGGCTTCGGCC  CATCCGACCGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Anthoptil  T-GTCGGATT----CGTCAAG  ACTCTGACGGAGGCTC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Eunicea    T-GTCAGATGGGTTTCGGGCT  CATCCGACCGGAC-GTC-AAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Anthothel  T-GTCAGATGGGCTTCGGGCT  CATCCGACGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Telestula  T-GTCGGATT----CGCAAG  AGCCTGACGGAC-GTC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Briareum   T-GTCGGATT----CGCAAG  ACTCTGACGGAC-GTC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Calcigorg  T-GTCAGATGGGCTTCGGCT  CATCCGACGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Melitella  T-GTCAGATAGGTTTCGACC  TATCCGACGGAC-GTC-AAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Siphonogo  T-GTCAGATGGGCTTCGGCT  CATCCGACGGAC-GTC-AAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Coelogorg  XXXXXXXXXXXXXXXXXXXXX  ATTCCGACGGAC-GTC-GAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Erythropo  T-GTCGGATT----CGAAAG  ACTCTGACGGAA-GTCCGAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  XXXXXXXXXXXXXXXXXXXXX
Junceella  T-GTCGGATT----CGCAAG  ACTCTGACGGAA-GTC-GAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Juncea2    T-GTCGGATT----CGCAAG  ATTCCGACGGAC-GTC-GAA  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Heliop2    XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXX
Plumigorg  T-GTCGGGTT----CGAAAG  AGCCTGACGGGCC-GCC-GAG  AAGTTGGTCAAACTTGATCA  TTT-AGAGGAAGTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Dendro2    CCTTGGTA-----CCTTCACG  GGTCCAAACGGTTTAGCCGAG  AAGTGCTCAAACTTGATCA  TTT-AGAGGAACTAAAAGTC  -GTAACAAGGTTTCCGTAGG
Selaginop  CCGTGCCGCAAGGAATGGTG  CCGGCC--------GAG  AACTTGCTCAAACATG---  --------  XXXXXXXXXXXXXXXXXXXXX
Beroe      GCCATGCCYGCGGAGGCAACGGC  GACACAGC-------GAG  AAGTTGANCAAAACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TTAACAGGTTTCCGTAGGTG
Mnemiopsi  CCGGCGGCCTTGTGTTGCCG  GCGCGCC-------GAG  AAGTTGGTCAAAACTTGATCA  TTTAGAGGAAGTAAAAGTCG  TTAACAGGTTTCCGTAGGTG
Scypha     CCTCTGGTCGGGCAACGCGCCT  ATGGGTTACC------GAG  AAGCTTTTCAAACCCGATCA  TTTAGAGGGAGTAAAAGTCG  TAACAGGTTTCCGTAGGGTG
Tripedali  GGCGTGACTTTACGGTGTGTG  CCAATTATC------GAG  AAGTTGATCACAAACTTGATCA  TCTAGAGGAAGTAAAAGTCG  TAACAGGTTTCCGTAGGTG
Trichopla  GGCGTGACTTTACGGTGTG  CCAATTATC------GAG  AAGTTGATCACAAACTTGATCA  TTTAGAGGAAGT--------  -----------------------
Tetilla    CCGTGGCAGGCGACTCGCCG  GGCGGATTTC-------GAG  AAGTCGATCAAAACTTGATCA  TTTAGAGGAAGT--------  -----------------------
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AnemoniaG  TGAAC
Hormathi1  TGAAC
Narellanu  TGAAC
Lepidisis  TGAAC
Orstomisi  TGAAC
Umbellula  TGAAC
Paramuric  TGAAC
Acanthogo  TGAAC
Taiaroa    TGAAC
Bellonell  TGAAC
Protoptil  TGAAC
Anthomast  TGAAC
Narellabo  TGAAC
Protodend  TGAAC
Tubipora   TGAAC
Paragorgi  TGAAC
Lophogorg  TGAAC
Chrysogor  TGAAC
Acanthopt  TGAAC
Clavulari  TGAAC
Corallium  TGAAC
Renilla    TGAAC
Stylatula  TGAAC
Virgulari  TGAAC
Leioptilu  TGAAC
Alcyonium  TGAAC
C_kischi   TGAAC
Lemnalia   TGAAC
Xenia      TGAAC
Calicogor  TGAAC
Euplexaur  TGAAC
Anthoptil  TGAAC
Eunicea    TGAAC
Anthothel  TGAAC
Telestula  TGAAC
Briareum   TGAAC
Siphonogo  TGAAC
Melitella  TGAAC
Calcigorg  TGAAC
Juncee2    TGAAC
Coelogorg  XXXXX
Erythropo  TGAAC
Junceella  TGAAC
Heliop2    XXXXX
Plumigorg  XXXXX
Dendro2    TGAAC
Selaginop  TGAAC
Beroe      -----
Mnemiopsi  AACCT
Scypha     AACCT
Tripedali  AACCT
Trichopla  AACCT
Tetilla    -----
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16. Abstract (Limit: 200 words)

This project assessed phylogenetic relationships within the Class Anthozoa (Cnidaria) using 18S rDNA sequences from 71 taxa, including museum specimens, providing the most thorough taxonomic sampling to date. Morphological taxonomists disagree over the evolutionary relationships within the Anthozoa. Sequence information and relevant evolutionary models were used to address subclass- and ordinal-level divisions within the Anthozoa. Nuclear 18S sequence information did not support some of the traditional classifications within the Anthozoa. Members of the Subclass Ceriantipatharia were genetically disparate, and phylogenetic divisions within the Anthozoa resembled the previous two-subclass system. The orders within the Hexacorallia constituted monophyletic groups with the exception of the Corallimorpharia, which were closely associated with the Scleractinia. The morphological characters of mesentery and tentacle structure were reflected in genetic structure of the Anthozoa. The morphological characters of skeletal structure and colony morphology were not evident in the phylogenetic divisions of the Octocorallia. The current orders and suborders were not monophyletic entities. Colony dimorphism corresponded loosely with genetic divisions within the Octocorallia. Half of the octocoral species included in this study formed a large, undifferentiated group, suggesting that a rapid radiation occurred. This project provides valuable insight into the evolution and diversity of these important organisms.

17. Document Analysis   a. Descriptors

18S rDNA
Maximum likelihood
Octocorallia

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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